Blind Admission? The ability of NSC maths to signal competence in university commerce courses as compared to the former SC Higher Grade maths

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Blind Admission? The ability of NSC maths to signal competence in university commerce courses as compared to the former SC Higher Grade maths.

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Abstract

Mathematics is an important signal used for admission into commerce courses in South African universities. In 2008 the new National Senior Certificate replaced the former Senior Certificate. This new exam no longer had different grades and thus created a structural break in the ability of the mathematics mark to signal preparedness for university. Although the Department of Education provided a “translation” key between the two Certificates, the University of the Witwatersrand (and other universities) admitted many more students in 2009 that met the entry requirements than previously. However, this cohort has lower average test and exam scores than previous years. This suggests that marks obtained for mathematics in the new National Senior Certificate are inflated when compared to the former Senior Certificate. This paper uses similar tests, for two commerce subjects, written by students in 2008 and 2009 to create a comparison between the mathematics marks under the two different certificates. The results suggest that marks in the range of 40-100% for Higher Grade mathematics for the Senior Certificate are now compressed into the 70-95% range for the new National Senior Certificate. This significantly weakens the ability of the school-leaving mathematics mark to signal the ability of students to cope with first year commerce courses.

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Introduction

In 2009 the intake of first year students, accepted to study at the University of the Witwatersrand (Wits) was significantly higher than in previous years. The majority of the students applying to Wits for entry in 2009 were also the first matriculants to obtain the new school leaving National Senior Certificate (NSC) instead of the former Senior Certificate (SC). Along with the expansion of the student body, there has been an observable decrease in the average test marks from 2008 to 2009 for first year commerce courses at Wits. We suspect that this is because the admission standards, especially the maths requirement, were set too low. The aim of this paper is therefore two-fold: firstly, to establish that the school maths mark is a good indicator of students' academic performance in commerce courses and therefore, fluctuations in the signal can lead to the inappropriate admission of students to commerce degrees; and secondly, to create a deflator of the NSC maths marks in order to establish a more accurate conversion key between the Higher Grade Matric maths marks of the former SC and the new NSC maths mark.

School marks as signals of academic ability

In the admission process, South African (SA) universities rely heavily on marks obtained in standardised school leaving exams, namely, the former SC exams (prior to 2008) and the new NSC (awarded from 2008 onwards). Universities treat these certificate marks as indicators not only of the applicants' current knowledge, but also of their ability to progress successfully in their studies in the future. This is only possible if school leaving exam marks are a consistently reliable signal of this knowledge and ability. Because school leaving exams are standardised nationally and quality controlled, the marks are seen as reliable signals of ability for universities countrywide when comparing students against one another and across time. This allows universities, based on observed correlations between previous students' marks in school subjects and their academic performance at university, to rank new applicants according to their ability to pass. If these marks are no longer reliable signals for ability, universities will have to find another way to determine ability and potential – possibly by administering their own entrance tests. An example of where this has happened is in the United States of America where high school marks are notoriously unreliable (Bishop & Mane, 2001, p. 204; Harman, 1994, p. 319) and universities have to rely on other standardised tests to measure ability. This is a resource intensive process (Arkes, 1999, p. 133) which would serve only to replicate one of the functions of the SA school leaving exams.

Understandably, SA universities cannot limit admission to only those students who have done well in the NSC exam because this would neglect the universities' responsibility to promote access and equity in favour of their responsibility to maintain quality (Herman, 1995, p. 271). The practice of using school marks as a signal of ability and the primary criterion for university admission is therefore not without its critics. In particular, critics argue that such a limitation would discriminate against students who may have the potential to do well at university, but have not been given the opportunity to achieve at high school level, in particular because of social conditions such as poverty and the attendant poor teaching conditions and lack of basic resources, and so have low school leaving certificate marks (Herman, 1995, p. 268). Some advocate using at least two main admission criteria (*Ibid* p. 337) in order to increase the efficiency of selection. However, this would still necessitate a reliable signal of ability so that universities can identify which students are likely to need additional support and to be able to provide this support.

Another criticism is that high school marks are measures of cognitive ability whereas there are other non-cognitive abilities that are equally important for doing well at university (Heckman & Rubinstein, 2001). These include qualities like persistence, motivation to succeed and self-discipline (*Ibid*, p. 146). Several papers have been written that attempt to measure how useful these qualities are as indicators of performance at university. Although some have found that they do have some predictive powers, high school marks are still better signals of ability and future performance at university (Latif Al-Nasir & Sachs Robertson, 2001, p. 284). This is because school marks do not only reflect what students know, but also what non-cognitive abilities they have (Mohammad & Almahmeed, 1988, p. 214). Research focused on investigating what variables are the best predictors of academic performance at university usually find academic performance at school to be the best predictor (Touron, 1987; Anderson, Benjamin, & Fuss, 1994; Betts & Morell, 1999). School marks may not be the perfect indicator for performance at university, but in SA they have proven themselves to be a good indicator (Parker, 2006, p. 142; van Walbeek, 2004, p. 880; Smith & Edwards, 2007, p. 99) and are probably the most parsimonious.[3] There will always be a trade-off between creating the best possible predictor for performance and the best use of scarce resources. In the SA context, where university resources are relatively scarce, interviewing each applicant to assess desirable non-cognitive abilities (see Latif Al-Nasir & Sachs Robertson, 2001, p. 284) is simply too costly.

In this context, for universities that rely so heavily on school leaving exam marks as a signal of ability, any structural break or significant fluctuations in the signal creates uncertainty which could lead to inefficient decision making with respect to student admissions.

This structural break happened in SA in 2008. The 2008 matriculants were no longer awarded the former SC on passing their exams, instead they were awarded the new NSC. These students have been taught using an outcomes based education (OBE) system instead of the old skills based learning system which used higher and standard grade courses. From the outset, the OBE system was inundated with criticisms and many were convinced that students would learn less than before (Rogan, 2007, p. 98; Cross, Ratshi, & Rouhani, 2002, pp. 180-183).

[3] For an indication of what can happen when admission criteria based on high school marks are suddenly lowered, one can look at Kuwait University which experienced failure rates so high that the admission criteria were reinstated (Mohammad & Almahmeed, 1988).

In addition to the curriculum changes that the new system entailed,[4] there was also a change in the approach to assessment and the marking system. Students are no longer assigned symbols based on a numerical mark for exams, but are instead assigned coded numbers that aim to indicate the level of proficiency obtained. Based on information provided by the Department of Education (DOE), higher education institutions like Wits developed a conversion key which allowed the admissions office to match the relationship between the former SC Higher Grade symbols and the new NSC levels.

Table 1: Higher Grade SC to NSC Conversion

Percentage	80-100	70-79	60-69	50-59	40-49	30-39	20-29	10-19	0-9
Higher Grade	A	B	C	D	E	F	G	H	I
NSC	7	6	5	4	3	2	1	1	1

Source: Wits Admissions Office, 2008

According to this key (replicated in table 1) students who passed maths on Higher Grade and obtained a "D" would now obtain a "4" under the NSC. Both of these marks were expected to reflect the same ability. Based on this information, the admission requirements to the various commerce degrees at Wits were "translated" according to the key above. It was hoped that this would result in students with more or less the same abilities as the previous year being admitted. When university registration numbers across SA increased noticeably, the DOE hailed it as evidence of the new curriculum's success.[5] While this might be true, the increase may also indicate that the comparative ranking of the old and the new marking systems was incorrect. Already in early 2009, parliament raised questions about the accuracy of the NSC Matric marks and the potential inflation of marks especially for subjects like maths (Parliamentary Monitoring Group, 2009a).

Many in the university community considered the standard of the 2008 NSC maths paper to be too low and proposed that it did not allow for an appropriate differentiation of ability among the top students[6]. However, the DOE claims that, except for the top end, the maths paper was of an acceptable standard and comparable to the former SC Higher Grade level[7]. However, there is very little quantitative evidence which attempts to compare the NSC exam marks with the former SC exam marks.

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[4] For an overview of the new OBE system and a description of how it differs from the former system see Cross, Ratshi & Rouhani (2002, pp. 178-179) and (Engelbrecht & Harding, 2008, pp. 59-61).

[5] Naledi Pandor, Minister of Education states that, "we are convinced that the quality standard we have set for these examinations, the *evidence of improvement* and the continuing commitment to achieve quality for all learners will deliver the promise of the Freedom Charter that the doors of learning and culture are indeed open and accessible for all the learners in our system." (2008, italics added)

[6] Nan Yeld from UCT argues that the NSC maths paper was too easy and Penny Vinjevold, Deputy Director General of Education states that "there wasn't enough differentiation at the top end, so that A's and B's were not a good predictor [of university success]" (Paton, 2009).

[7] Penny Vinjevold, Deputy Director General of Education, states that "if you got 50% for [the 2008 NSC maths] paper, then you were at [the former] higher grade level" (Paton, 2009).

One initiative to investigate the comparability of the two learning systems is the National Benchmark Test (NBT) which was commissioned as early as 2005 by Higher Education South Africa (HESA). Its purpose is to:

- assess entry-level academic literacy and numeracy/maths proficiencies of learners;
- assess the relationship between entry level proficiencies and school-level exit outcomes; and
- provide a service to institutions requiring additional information in the admission and placement of entry level students.

In particular, it is supposed to provide supplementary information about the abilities of students who have written the NSC exams. The NBT aims to answer questions that some may have about how to interpret and value the new NSC marks (Parliamentary Monitoring Group, 2009b). The test investigates three core areas of performance, Academic Literacy, Quantitative Literacy and Maths. It then classifies students in these core areas according to three levels, proficient, intermediate or basic. The levels are defined according to how difficult or easy it will be for students to progress in higher education institutions (Parliamentary Monitoring Group, 2009). The information is supposed to help universities to identify students who need support, correctly place students and develop better curricula (MacGregor, 2009).

The results of the NBT in 2009 are worrying. Of the 13 000 participating students across various South African universities[8], only 43% were proficient in academic literacy, 25% in quantitative literacy and a mere 8% in maths (Paton, 2009).

Unfortunately, the NBT pilot was only administered in early 2009 which implies that the findings of the 2009 NBT could not be used to determine the ability of the 2009 students prior to their admissions. Furthermore, the fact that we do not have NBT marks for the 2008 first year students, denies us the opportunity to directly compare the signaling ability of the new NSC maths mark with the former SC maths mark with respect to the student's academic achievement. In order to investigate this, we use two compulsory first year commerce courses at Wits and compared the performance of the 2008 student cohort that wrote the last former SC maths exam at the Higher Grade level with the 2009 student cohort that wrote the new NSC maths. In particular, we investigate the ability of the NSC maths mark to predict a student's academic performance and compare it to the ability of the former SC Higher Grade maths mark to predict academic performance.

[8] The 2009 NBT was implemented at the University of Cape Town, University of the Western Cape, Stellenbosch University, University of Kwa-Zulu Natal, Mangosuthu University of Technology, Wits and Rhodes University (Monday Paper, 2009)

Commerce courses at Wits

For commerce related subjects like Economics, Accounting and Actuarial Sciences, school maths marks are considered to be good predictors of academic competency (Varua & Mallik, 2008; Corne Van Waalbek, 2004). Therefore, when comparing the admission requirements of most commerce faculties in SA (see, for example the 2010 admission requirements at Wits, University of Cape Town and Stellenbosch University), most faculties require a relatively high maths mark and put significant emphasis on the maths mark as a requirement for admission. Across all universities, commerce degrees require at least a pass for maths (NSC level 4) or more and do not admit students who have studied Mathematical Literacy[9].

Furthermore, it is quite common that commerce faculties require their students to take a commerce specific maths/statistics course to ensure that all students are able to use standard maths and statistics applications. At Wits, all commerce students have to register for the first year Computational Maths[10] course, a terminating service course in mathematical skills for students. The emphasis of the course is less towards the development of mathematicians and more towards the practical use of mathematical tools in business and economic applications.

In 2009, the number of commerce students at Wits increased unexpectedly by 25% when compared to 2008. As part of the commerce curriculum, all commerce students have to register for Economics 1[11], Accounting and Computational Maths. While Accounting and Computational Maths are only offered to commerce students, Economics 1 is offered across faculties and draws students from the Humanities, Science, Engineering and Commerce.

Commerce tests comparisons

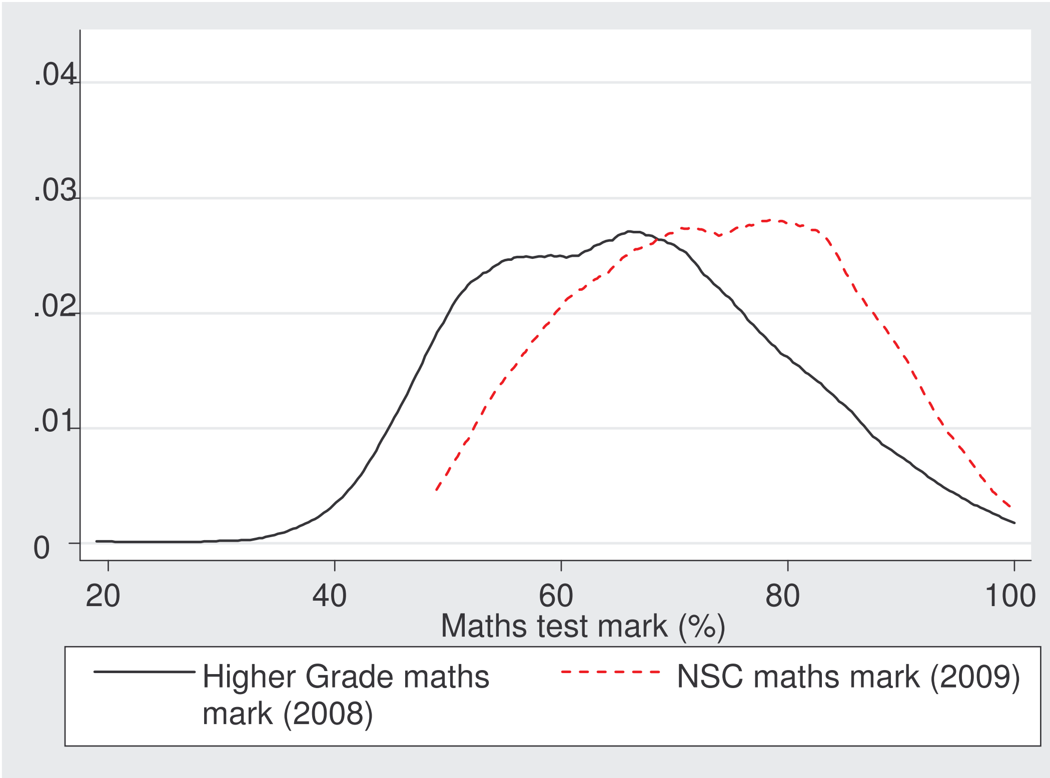
As graph 1 shows, the 2009 first year student cohort achieved a higher average maths mark in their school leaving exam relative to the 2008 1st year student cohort. If the conversion key is correct, this should indicate that the 2009 cohort should perform much better than the 2008 cohort.

[9] Under the former SC, maths courses were divided into standard and higher grade courses. As part of the new NSC, the distinction between standard and higher grade courses was abolished and students would do Maths or Mathematical Literacy. The NSC maths reflects the same formal approach to the study of maths as the former higher and standard grade mathematics of the former SC. However, Mathematical Literacy is an entirely different subject with the focus on showing how maths relates to situations and problems of life. It is therefore not the equivalent of the former Standard Grade maths.

[10] APPM1004 is the Computational Maths course code used by Wits.

[11] ECON1000 is the Economics 1 course code used by Wits.

Graph 1: Distribution of SC Higher Grade maths and NSC maths marks of 2008 cohort and 2009 cohort



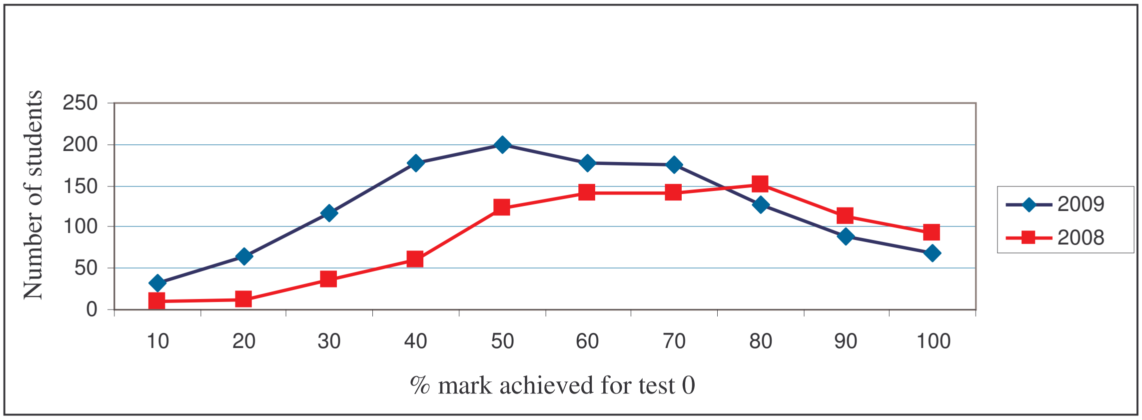
However, staff members became skeptical about the ability of the new NSC marks to convey the real academic ability of the new students. Anecdotal evidence from lecturers suggested that students did not have the capability to comprehend lecture material that required numerical aptitude. This led various first year course coordinators in the commerce faculty to compare the performance of the 2009 cohort with the previous year's cohort. In particular, the Computational Maths course and the Economics 1 course deliberately set tests in the first block of 2009 that were very similar to the tests written in the first block of 2008. The tests are the introductory test (test 0) for the first year Computational Maths course and the first test (test 1) of the first year Economics course. The purpose of this was to compare the performance of the 2009 cohort with the performance of the 2008 cohort.

The introductory Computational Maths test is comprised of 25 multiple choice questions (MCQ), each with five alternatives of which only one is correct. The choice of items is related to the essential basic mathematical skills that students entering the course would be expected to have learnt at school. The items aim to test for common errors and gaps in knowledge, which had been observed by the teaching staff, experienced by students who struggled the most with the course content of Computational Maths. Some of the alternatives are common errors which indicate serious impediments to the progress of students in Computational Maths, whilst others are random distracters. Negative marking was employed for incorrect alternatives.

The test was referred to as the ‘Intro Test’ or ‘Test 0’ to distinguish it from the five Class Tests, Test 1 – Test 5, that contribute towards the year mark for the course. Students were informed that Test 0 would not contribute towards their year mark but that it was very important that they write the test and that their absence would be officially noted. As a further incentive they were told that it was an important practice run for the use of computer cards in multiple choice testing at Wits. The students were also informed that the content of the test would comprise ‘school maths’.

Graph 2 shows the test mark distribution of the introductory Computational Maths test for the years 2008 and 2009.

Graph 2: First year Computational Maths, test 0 comparison: 2008 vs 2009



Year	0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	Total
2008	10	12	37	61	123	141	142	152	113	93	884
2009	32	65	116	177	199	178	175	128	89	68	1227

Source: Wits University, Computational Maths, own calculations

As can be seen from graph 2 and the attached data table, whilst the actual number of students in the upper mark categories is similar for both years, the number of students in the lower mark categories (<50%) diverges markedly, with the number of failures in 2009 higher than in 2008. The total number of students writing in 2009 was 39% greater than the number writing in 2008 and yet it seems that the additional students in 2009 fall almost entirely into the fail category. The increase in the number of students failing is almost exactly the increase in the total number of students registered for the course in 2009.

This result led to great concern among the lecturers in the course because in general, there was a subjective assessment that, given the time constraint and possible lack of motivation amongst students, a mark of at least 60% would indicate an acceptable level of competency and that anything lower than this would indicate serious problems. Table 2 compares the competency of students, assuming that 60% indicates a competent student. Only 37% of the 2009 cohort managed to reach the competency level compared to 57% in 2008.

Table 2: Competence rates of 2008 and 2009 cohort in APPM test 0

Year	Registered students for APPM 1004	Students getting ≥ 60%	Competent students: % ≥ 60%
2008	884	500	57%
2009	1227	460	37%

Source: Wits University, Computational Maths, own calculations

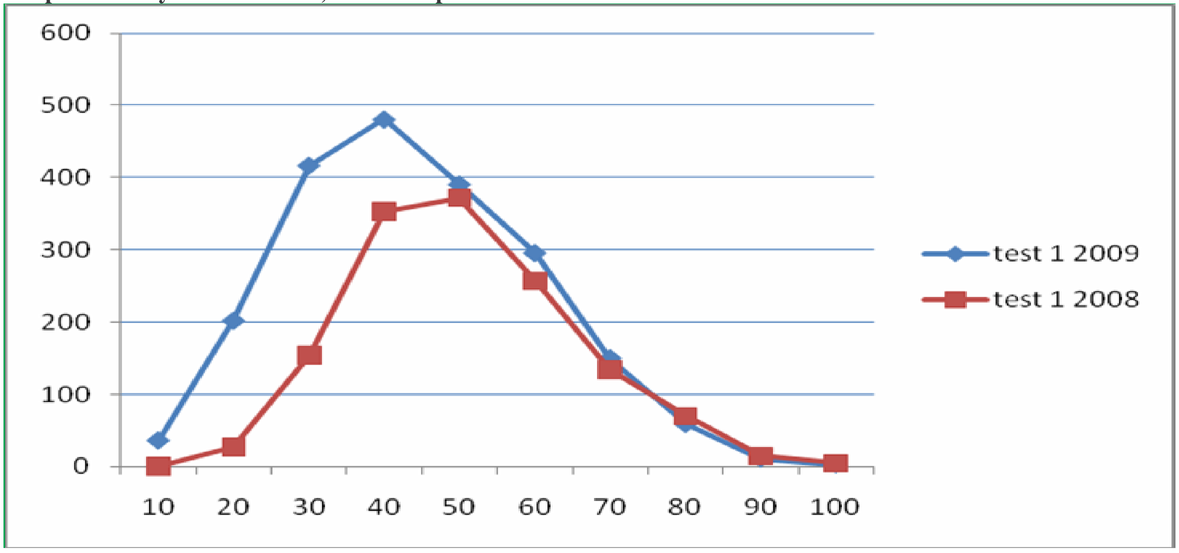
The results of the introductory Computational Maths test 0 illustrate that the 2009 cohort struggles with standard mathematical skills of an algebraic nature, a finding which was eventually confirmed by the results of the NBT. This raises the question of whether or not other commerce courses are equally affected.

The case of economics is particularly interesting. While economics is a quantitative subject, it is still considered a social science, where conceptual understanding and the ability to argue are crucial. It is certainly worth investigating whether or not new NSC maths curriculum and OBE can provide students with the necessary set of skills to comprehend economic problems and to solve them.

Similarly to the Computational Maths test, the first Economics 1 test consists of an MCQ section and an additional written section. The written section is generally maths related requiring the interpretation of graphs and calculations. The MCQ section includes mathematical questions as well as conceptual questions. Test 1 in 2009 was closely modeled on test 1 in 2008. The main changes were in the numerical examples and the direction of changes (e.g. instead of increasing a variable it was decreased) and students had to interpret and/or predict the new outcomes.

Graph 3 shows the test mark distribution of the first Economics 1 test for the years 2008 and 2009.

Graph 3: First year Economics, test 1 comparison: 2008 vs 2009



Year	0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	Total
2008	1	27	154	353	372	257	134	70	15	5	1388
2009	36	202	417	481	391	296	150	59	11	3	2046

Source: Wits University, Economics 1, own calculations

From graph 3 (and data table) we see that in 2009 Wits accepted an extra 658 students to study Economics 1. The results of the Economics 1 test comparison are very similar to the findings from the Computational Maths course. While the number of students in the upper deciles are close to identical, almost the entire additional student body (620 students) of the 2009 cohort is in the fail category (<50%). This represents 94% of the additional students admitted and confirms the findings revealed by the Computational Maths results.

The test comparisons of the two commerce courses suggest that the NSC maths marks of the 2009 cohort are not reliable signals of the students' academic ability and that the university has admitted students who do not have the necessary set of skills to pass commerce courses. However, a simple comparison of the two tests across different years might be misleading. Both test mark distributions for the Computational Maths course and the Economics 1 course show the entire sample of students who are registered for the courses in 2008 and 2009 respectively. This includes repeat students, foreign students and older students, who have matriculated long before 2007. Also, the 2009 cohort might be a very different draw of students, i.e., while the 2008 cohort might have been a "strong" year, the 2009 cohort might be a "weak" year.

To compare the signaling ability of the maths mark of the former SC to the new NSC maths, we needed to control for any other factor that might affect academic performance. Thus, we needed to compare first year students who entered the university in 2008 after completing Matric in 2007 only with first year students who have similar individual characteristics as the 2007 students but entered the university in 2009 after completing NSC in 2008. This will allow us to isolate the impact of the difference between the students maths ability on his/her academic performance.

Descriptive statistics of the 2008 and 2009 1st year commerce student at Wits

The individual student data for the 2008 and 2009 1st year student cohorts is drawn from the Wits Student Records. Students were removed from the sample if they: 1) wrote their school leaving exams prior to 2007 or in a different country; 2) repeated their school leaving exams in 2007 and 2008, i.e., wrote the SC as well as the NSC exams; 3) did not report their personal and/or school specific information on their student files; and 4) did not write both the first Economics test and the Computational Maths test. This delimitation created a sample of 1445 1st year students of which 546 and 896 were enrolled in 2008 and 2009, respectively.

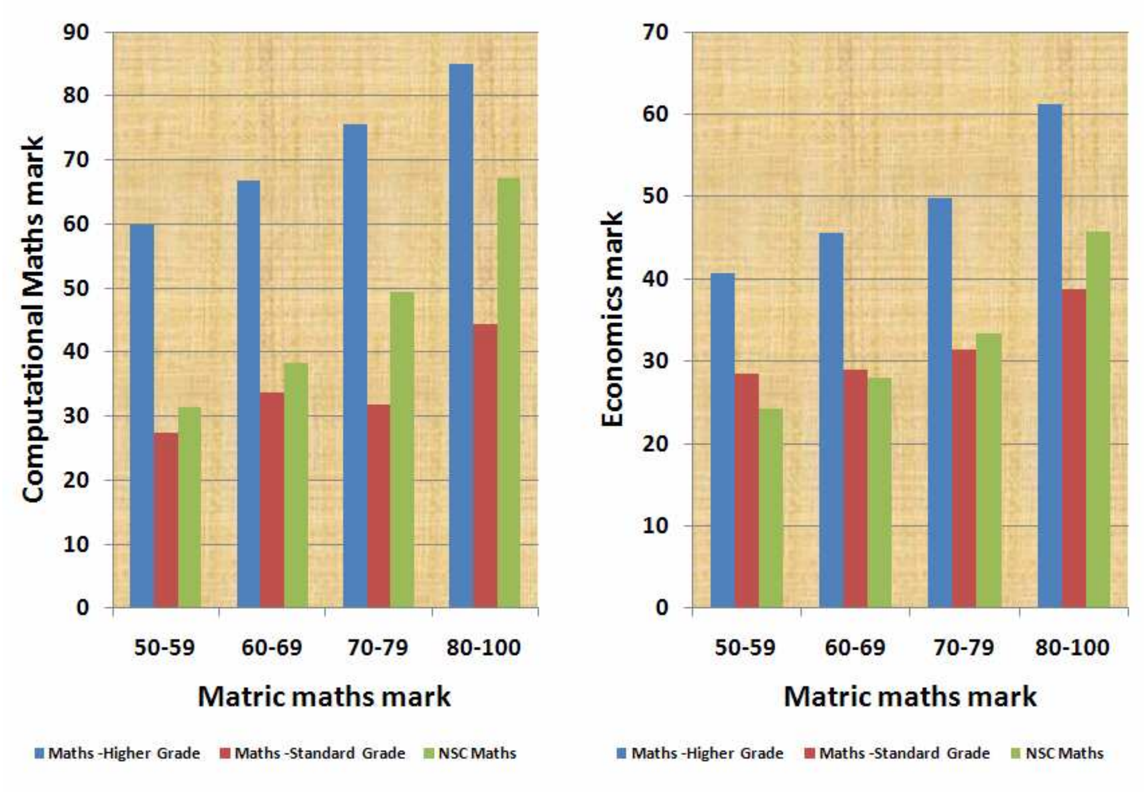
Table 1A in the appendix shows the summary statistics of the individual, school-related and university variables by each enrollment cohort (2008 and 2009) and for the full sample. In particular, table 1A shows the variables' means, standard deviations, minimum and maximum values.

The data show that the draw of the 2009 student cohort is in some aspects different to the 2008 cohort. In contrast to the 2008 cohort, the 2009 cohort is on average one year younger with only 41% coming from English speaking households compared to 57% in 2008. While the gender breakdown is similar in both years, the 2009 cohort contains a significantly higher number of African students (60% of entire cohort in 2009) compared to 2008 (44% of the entire cohort). Furthermore, while in both years Wits draws most of its students from Gauteng (above 70%) there is a significant increase of students enrolling in 2009 from provinces outside of Gauteng, especially from Limpopo, Mpumalanga and North West. Finally, the university has granted a larger number of student bursaries in 2009 which could indicate that a greater number of students came from financially weaker households.

The descriptive statistics also illustrate that the school leaving NSC maths mark of the 2009 cohort is on average 6% higher than the average Higher Grade maths mark in 2008. The minimum marks show the admissions requirements for the respective years. In 2008, students had to achieve at least 40% in Higher Grade maths or 60% in Standard Grade maths while for a 2009 student the minimum requirement was 50% in NSC maths. Irrespective of the higher maths mark, the 2009 cohort underperformed in both course tests. At the university level, students in both cohorts performed better in the Computational Maths test than in the Economics 1 test. Despite this commonality between both cohorts, the 2008 cohort had higher mean marks for both tests than the 2009 students. For instance, in 2008 the mean mark for the Economics test was 46 %, while 2009 was 10 % lower. The difference is even higher for the Computational Maths test where the 2009 cohort scored on average 15% lower.

To illustrate the relationship between the school leaving maths mark and the students' university performance, Graph 4 shows the mean differences for both the tests by Matric maths mark, i.e. the students' performance in Higher Grade and Standard Grade SC maths and NSC maths. The figure suggests a positive correlation between the students' school leaving maths mark and their performance in both the Computational Maths test and Economics 1 test. This possibly suggests that high school performance is a fair indicator of a students' innate ability. Nonetheless, some differences are also observable from the graph; students who did Higher Grade maths at school got higher marks in both tests than those who did Standard Grade and NSC maths.

Graph 4: Computational Maths test 0 and Economics 1 test 1marks by Matric maths marks



The mean difference tests for the Computational Maths test and Economics 1 test by gender, home language (i.e. whether English is a student's home language or not), and financial aid allocation were also conducted. The findings are presented in Table 5.

Male students generally scored slightly higher marks in both tests than their female counterparts. However, this difference is only statistically significant for the 2009 cohort. It is also evident that an English language "premium" seems to exist in the students' performance. As such, English home language speakers scored higher marks than those who speak English as a second language. Table 5 also reveals that, for both tests, students who do not receive financial aid from the university perform better than their recipient counterparts across the cohorts. Moreover, this gap is statistically significant at the 1 % level. This disparity might imply that financial need is a proxy for other factors (such as poor previous educational background) which have adverse effects on university performance. Another finding is that the correlation between the students' mean marks for the Computational Maths test and staying on campus is not statistically different from the mean marks of those who stay off campus. However, the relationship differs with regard to the Economics test; resident students have a slightly higher mean than non-residents and the difference is significant at the 5 % level.

Table 5: tests for test0 and test1 differences in mean by demographic characteristics

Variable	Group	Full sample	2008 Cohort	2009 Cohort
Economics test	Male	40.949	47.182	36.898
	Female	38.530	45.750	34.260
	P-value	*0.045*	*0.2570*	*0.0114*
CompMaths test	Male	59.184	67.753	53.683
	Female	54.493	64.612	48.537
	P-value	*0.0000*	*0.067*	*0.0002*
Economics test	English home-language speakers	44.194	48.637	40.365
	English second language speakers	35.576	43.478	32.033
	P value	*0.0000*	*0.0000*	*0.0000*
CompMaths test	English home language speakers	64.033	70.792	58.518
	English second language speakers	49.910	59.892	45.479
	P value	*0.0000*	*0.0000*	*0.0000*
Economics test	Wits residents	42.398		
	Wits non-residents	39.168		
	P-value	*0.0397*		
CompMaths test	Wits residents	58.392		
	Wits non-residents	56.358		
	P-value	*0.2249*		
Economics test	Financial aid recipients	33.062		
	No financial aid recipients	40.490		
	P-value	*0.0000*		
CompMaths test	Financial aid recipients	47.278		
	No financial aid recipients	57.860		
	P-value	*0.0000*		

The means for Wits residency and financial aid were only carried out on the full sample due to the small sample sizes of both the students who stay in halls of residence and those who receive financial aid .

Methodology

The descriptive analysis of our student cohorts confirms the strong correlation between achievement in high school maths and commerce courses. In this paper we exploit this relationship in order to estimate the predicted mark for Higher Grade mathematics for students that wrote NSC mathematics. To compare the 2008 maths mark with the 2009 maths mark, we have to match the 2008 Standard Grade maths marks with the Higher Grade maths marks so that all students in the 2008 cohort have Higher Grade maths marks only. We do this by deflating the mark for Standard Grade maths by 20% to convert it to an equivalent Higher Grade mark. This is in line with the conversion used by Wits for acceptance into the general B.Com in 2008.

To create the comparison between the two cohorts, we start by estimating a regression of the following form on the 2008 first year students sample:

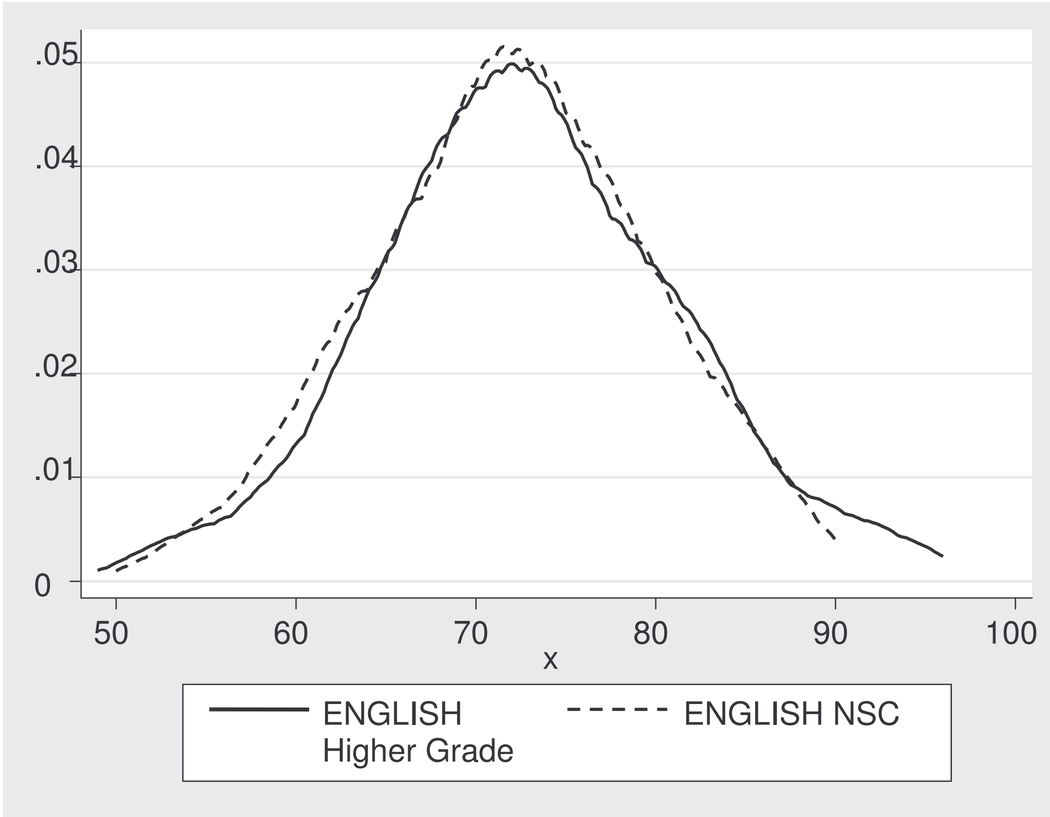
$$y_i = \alpha + X_i'\beta + \chi english_i + \delta test_i + \varepsilon_i$$

Where:

y_i is the result that an individual obtained for school leaving maths exam;
α is the constant term;
x_i is a vector of individual specific characteristics including gender, race, home province, whether the individual lives in residence and whether the individual has financial aid;
english is the result that an individual obtained for school leaving English exam;
test is the test mark that an individual achieved in either the Computational Maths test 0 or the Economics 1 test 1. In order to allow for a non-linear relationship we also introduce a squared-term.
ε_i is an error term.

We include the individual student's mark for English at school level in order to control for the student's academic ability. The fact that all students have done English as part of their school leaving exams explains our decision to include only English as a further school subject in our regression.

Graph 5: Kernel density distributions of NSC English results and Higher Grade English results



Home language and first language have been combined for the NSC and first language and second language have been combined for the SC. The similar distributions shown in graph 5 suggest that results for the two years (2008 and 2009) are comparable.

The relationship between the Higher Grade maths mark and the student's performance in the Computational Maths test0 and the Economics 1 test is estimated using Ordinary Least Squares (OLS). A number of different specifications are used in order to check the robustness of these results. The results from these regressions are then used to predict what the NSC students would have scored if they had written the 2007 Higher Grade maths based on their individual characteristics and what they scored for Computational Maths test 0 or Economics 1 test 1.

To illustrate this procedure, assume that we take an individual X of the 2009 cohort who has written the 2008 NSC maths and scored 50% in the 2009 Economics 1 test. That individual has the following observable characteristics: African, male, 20 years old, from Gauteng, matriculated from School Y, with Zulu as the home language, staying with his parents, etc. We then use these observable characteristics (obtained from the admissions office) in order to predict how the same student would have performed in the 2007 Higher Grade maths SC exam. The prediction uses the results from the above regression and imposes the obtained coefficients from the 2008 1st year students sample onto the 2009 individual X based on the average Higher Grade maths mark of individuals of the 2008 cohort who also scored 50% in the 2008 Economics 1 test and fit the same observable characteristics (African, male, 20 years old, from Gauteng, matriculated from School Y, with Zulu as the home language, staying with his parents, etc.).

Regression analysis and prediction

Table 6 shows the results from the first set of regressions for the Computational Maths test 0. Column 1 and 3 impose a linear relationship between test 0 and Higher Grade maths whilst column 2 and 4 allow for a non-linear relationship. Columns 1 and 2 do not control for home province. This is done to increase the sample size since we do not have this information for some of the individuals.

The linear specifications (columns 1 and 3) suggest a significant positive relationship between the mark in Computational Maths test 0 and Higher Grade maths. An increase of 1% for test 0 is associated with a 0.36% higher result in Higher Grade maths. The non-linear specifications suggest that this relationship is convex. This relationship is declining up until 53% for test 0 but thereafter increases at an increasing rate. This initial declining relationship is due to a small number of individuals (three) with relatively high SC maths marks that scored below 10 % on the test 0. Nevertheless, these findings confirm that the applicant's school maths mark is a good predictor of academic ability.

Contrary to the descriptive statistics, the regression results indicate that across the specifications there is no significant difference in Matric maths marks between males and females holding other characteristics constant. Also, while the negative coefficient indicates that African students scored on average less than Whites, the difference between the two groups is not statistically significant. There is also no significant difference between Whites and Indians. Coloureds, on the other hand, scored between 3.7 and 4.9% less than Whites. Furthermore, speaking English as a home language is not significantly associated with Matric maths marks, while the school leaving mark for English as a subject is strongly correlated with the maths mark of the student. This seems to indicate that good students perform well across school subjects. There is no significant difference in Matric maths between financial aid and non-financial aid students, but those living in university residence scored between 3.1 and 4.2% higher than non residence students. This is expected, as the allocation of residence is often based on financial need as well as school performance. Applicants with higher Matric marks are therefore more likely to be offered a place in a university residence.

Table 6: Regression results for APPM 1004 test 0 (various specifications)

	(1)	(2)	(3)	(4)
VARIABLES	MATHS_Higher Grade	MATHS_ Higher Grade	MATHS_ Higher Grade	MATHS_ Higher Grade
Test0 (APPM)	0.360***	-0.314***	0.362***	-0.334***
	(0.0256)	(0.106)	(0.0269)	(0.104)
Test0 squared		0.00552***		0.00568***
		(0.000819)		(0.000808)
English	0.392***	0.366***	0.399***	0.376***
	(0.0564)	(0.0543)	(0.0607)	(0.0580)
Male	1.001	0.632	0.615	0.235
	(0.850)	(0.799)	(0.870)	(0.816)
Home language (English)	0.286	0.493	0.788	1.074
	(1.554)	(1.542)	(1.614)	(1.596)
African	-2.286	-1.912	-2.247	-1.834
	(1.657)	(1.625)	(1.715)	(1.678)
Coloured	-4.954***	-3.714**	-4.917**	-3.708*
	(1.826)	(1.839)	(2.070)	(2.085)
Indian	0.187	0.521	-0.276	0.0836
	(1.076)	(1.045)	(1.132)	(1.098)
Free State			1.300	2.272
			(2.861)	(2.771)
Eastern Cape			0.565	0.662
			(2.196)	(2.175)
KwaZuluNatal			1.592	1.265
			(1.599)	(1.578)
Limpopo			4.114*	3.428*
			(2.309)	(1.918)
Mumpumalanga			-1.741	-2.820
			(2.048)	(1.828)
North West			1.207	1.517
			(3.080)	(2.933)
Northern Cape			10.81***	12.97***
			(1.067)	(1.010)
Western Cape			-1.120	-1.943
			(1.852)	(1.758)
Financial Aid	1.216	0.847	2.159	1.773
	(1.421)	(1.319)	(1.470)	(1.333)
WITS_RESIDENT	3.171***	3.587***	1.926	2.512*
	(1.180)	(1.099)	(1.407)	(1.336)
Constant	13.74***	33.77***	12.98***	33.38***
	(4.502)	(5.326)	(4.768)	(5.551)
Observations	621	621	586	586
R-squared	0.485	0.525	0.491	0.533
*** p<0.01, ** p<0.05, * p<0.1; Robust standard errors in parentheses				

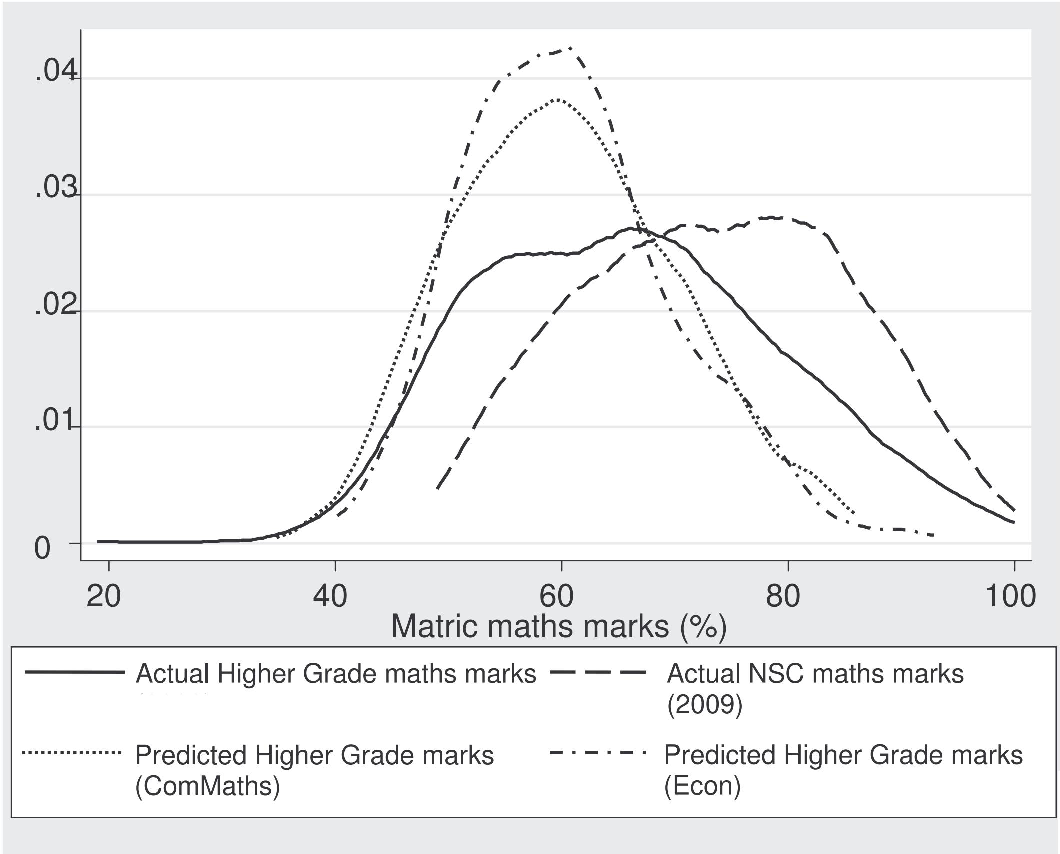
Table 2A in the appendix shows the regression results using the Economics 1 test. The results from the linear specification are remarkably similar to those obtained for Computational Maths test 0 – a 1% increase in the mark obtained for Economics test 1 is associated with a 0.42% higher mark for Matric maths. The non-linear specification, however, does not confirm a convex relationship. Furthermore, the high correlation between the student's performance in SC maths and English is confirmed. Correspondingly, the results on the individual characteristics are similar, although in this specification Coloureds mark approximately 7-8% lower for the former SC maths than Whites.

The results from the regressions are then used to predict the Higher Grade maths mark that the NSC students would have scored based on their individual characteristics and the results that they scored on the Computational Maths test 0 and the Economics 1 test 1.

Graph 5 presents the kernel density function of the predictions based on the specifications that control for province (column 3 in the estimations). As was shown in the descriptive statistics, the average Matric maths mark of the NSC matriculant (i.e. 1st year students in 2009) exceeds the average Matric maths mark of the Higher Grade matriculant (i.e. 1st year student in 2008) in the region of 6%.

In graph 6, the solid line is the distribution of Matric Higher Grade maths marks of the 2008 cohort and the long, dashed line is the distribution of the 2009 cohort's NSC maths marks. Simply comparing these two distributions suggests that the NSC distribution is merely shifted to the right, suggesting that the university accepted students with a higher maths ability. However, the predicted Higher Grade results from the estimations (dotted – using Computational Maths, dotted/dashed – using Economics 1) suggest that this is not the case. Instead, the faculty accepted a higher proportion of students with relatively weak predicted Higher Grade maths marks. In fact, many of those accepted would have scored less than 50% for Higher Grade maths. As graph 1A in the appendix shows, this finding also holds for the non-linear specification.

Graph 6 – Actual and predicted Matric maths mark distribution (linear with provinces)



In order to further interrogate whether the university used the correct conversion key between the new NSC maths mark and the former SC Higher Grade maths mark we compare the actual NSC marks of the 2009 1st year students against their predicted Higher Grade marks. Table 8 reports the average actual NSC mark obtained for categories of predicted Higher Grade marks.

The contrast between the two sets of marks is stark. Students of the 2009 cohort with a predicted Higher Grade maths mark in the range of 40–49% (Higher Grade symbol "E") actually achieved an observed average NSC maths mark in the range of 64–66%. This increases to 68-69% for those predicted to mark a "D" (50-59%) in Higher Grade maths. The maths marks only converge towards the upper end of the spectrum.

Table 8: Actual NSC marks for predicted Higher Grade categories

Predicted Higher Grade Percentage		80-100	70-79	60-69	50-59	40-49	30-39
Matric Higher Grade symbol		A	B	C	D	E	F
Actual NSC percentage							
Computational Maths (linear & provinces)	Mean	92.44	85.73	77.40	69.11	63.60	56.42
	Std dev	3.88	7.37	9.77	9.42	8.03	4.96
Computational Maths (non-linear & provinces)	Mean	91.02	86.39	77.99	67.76	66.28	-
	Std dev	4.76	7.31	10.03	9.37	9.37	-
Economics 1 (linear & provinces)	Mean	90.42	85.21	77.12	68.28	65.17	-
	Std dev	5.16	8.38	10.17	9.99	8.99	-
Economics 1 (non-linear & provinces)	Mean	89.70	85.80	77.01	67.95	65.54	-
	Std dev	5.94	7.89	10.20	10.03	8.54	-

The main limitation of the above procedure is the potential impact of cohort effects on the predicted results. As the descriptive statistics have shown, the composition of the 2009 cohort is different to the 2008 cohort. For instance, the 2009 cohort has got a significantly higher number of African students as well as a lower number of English home language speakers While the above prediction tries to control for this, the reported NSC mark is the average mark of a group of students that are predicted to fall within a particular Higher Grade band. Thus, the composition of these groups potentially affects the average.

To test the robustness of the above results and to eliminate the potential impact of the differences in the composition of the two cohorts we use propensity score matching as an alternative approach. The advantage of propensity score matching is that we first match individuals from the 2008 cohort with individuals from the 2009 cohort that are "similar" in their observed characteristics as used in the regressions in table 6 and 2A. Thus, we construct a sample of the 2009 cohort that is as similar as possible to the 2008 cohort with respect to their observed characteristics. We then compare the Higher Grade maths mark of the 2008 1st year student with the NSC maths mark of the 2009 1st year student with similar observable characteristics[12]. The propensity score matching process identified 260 matches for the Computational Maths test and 230 matches for the Economics 1 test.

As table 3A in the appendix shows, the NSC maths mark of the matched 2009 1st year student is on average between 12-13% higher than the Higher Grade partner's maths mark. This difference is statistically significant. However, this is the average and across all matches and not along the distribution. Table 10 reports the mean and median NSC maths mark of 2009 1st year students compared to their matched Higher Grade partners grouped in the actual Higher Grade bands they scored. The results suggest that the former Higher Grade E (40-49%) is equivalent to, on average, between 70-72% in the new NSC maths when comparing similar first year students across the two years. This is

[12] The variable "maths" in the propensity score matching compares the NSC maths marks with Higher Grade maths marks including the converted Standard Grade maths marks.

significantly higher than the previously predicted 64-66%. Furthermore, the results suggest that the NSC mark does not sufficiently discriminate for the student's ability, but rather compresses students with substantial differences in ability indicated by their matched Higher Grade partners (range between 40-100%) into a limited range of only 30% (between 70- 100% in NSC marks). Thus, the ability of a NSC matriculant who obtained a maths mark between 70–80% could be anywhere on the scale of ability of Higher Grade matriculants that obtained between 40% and 80%.

Table 10: Comparison of NSC maths marks with Higher Grade matched partners (Propensity score matching)

Percentage category		**80-100**	**70-79**	**60-69**	**50-59**	**40-49**	**30-39**
Matric Higher Grade symbol		**A**	**B**	**C**	**D**	**E**	**F**
NSC student							
(Computational Maths test 0)	Mean	82.20	79.11	76.96	72.86	72.33	58
	Median	85	79.5	79	73	72	58
	Std dev	11.68	11.58	10.92	11.43	11.91	-
Higher Grade matched partner							
(Computational Maths test 0)	Mean	85.92	72.95	64.63	53.9	45.2	39
	Median	85	72	65	54	46	39
	Std dev	5.27	2.58	2.89	2.66	3.19	-
	Number of matches	39	44	85	61	30	1
NSC student							
(Economics 1 test)	Mean	81.15	75.59	76.05	76.19	70.4	67
	Median	79.5	77.5	76	77	69	67
	Std dev	9.06	11.34	13.09	10.62	11.39	-
Higher Grade matched partner							
(Economics 1 test)	Mean	85.12	73.29	65.01	54.5	45.3	39
	Median	83.5	73	66	54	46	39
	Std dev	4.86	2.54	3.15	2.87	3.16	-
	Number of matches	32	44	70	63	20	1

We can use the findings of the predictions and the propensity score matching to develop a more appropriate conversion key between the NSC maths mark and the Higher Grade maths mark based on the performance of the students in the two commerce courses. Table 11 outlines the relationship between the two maths marks.

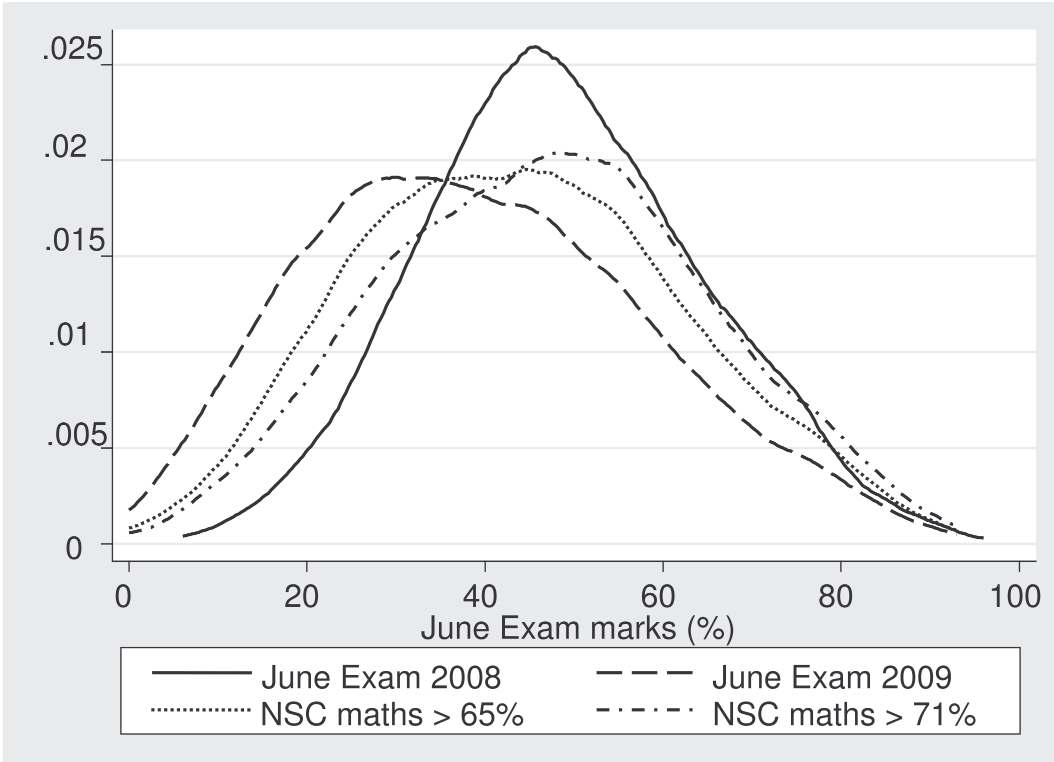
Table 11: Former SC Higher Grade to new NSC Conversion based on Commerce test marks

Percentage	80-100	70-79	60-69	50-59	40-49	30-39	20-29
Higher Grade	A	B	C	D	E	F	G
NSC (Applied key)	7	6	5	4	3	2	1
NSC (predicted)	7	7	6	5	5	4	4 & less
NSC (propensity score match)	7	6	6	6	6	5(?)	

In 2008, Wits accepted students into the general B.Com with an E (40%) for Higher Grade maths. In 2009, the admission requirement was a minimum of level 4 (50%) for NSC maths. However, table 11 suggests that in order for the university to admit students who achieved at least a "E" (40-49%) for Higher Grade maths, the level in 2009 should have been at least level 5 (65% according to the predicted NSC) if not closer to level 6 (71% according to the propensity score matching). This still raises the question of whether the 2009 student cohort with an entrance requirement equivalent to the NSC level 5 (68%) or level 6 (73%) would have done as well as the 2008 student cohort. In order to check this we present in figure 5 the distribution of exam marks for the Economics 1 June 2009 exams for these new cut-offs and compare them to the distribution in 2008. Using the June exam instead of the two tests (Computational Maths test 0 and Economics 1 test 1) has two advantages: first, after one whole semester, first year students are more likely to have adapted to the university standards of assessment. Thus, if the outcomes-based approach of OBE presented students with a disadvantage while the former skills based approach of the SC was more aligned with the university testing, then potentially students in 2009 might have changed their approach by the end of the first semester, i.e., for the June exam. Secondly, using the new entrance requirements to compare the distribution of marks for the Computational Maths test 0 or the Economics test 1 would create a circular argument. This is because the tests which are used to create the predicted entrance requirement would then be used to evaluate the usefulness of the predicted entrance requirements., i.e., the inputs in obtaining the predictor are the same as the outcome which the predictor is supposed to establish.

Graph 7 illustrates that even when we impose an admission requirement of 65% for NSC maths (dotted line) the limited sample of first year students in 2009 would still not produce a similar distribution of June exam marks equivalent to the distribution of June exam marks of the 2008 cohort. Only the higher cut-off of at 71% (dotted/dashed line) for NSC maths creates a sample of the 2009 student cohort that achieved a similar mark distribution compared to the 2008 cohort.

Graph 7: June exam mark distribution of 2008 compared to 2009 (different NSC entrance requirements)



However, even when we impose the 71% cut-off, the 2009 cohort contains a significantly higher portion of students who achieved less than 30% in the June exam compared to the 2008 cohort. This indicates that NSC maths maths simply does not differentiate sufficiently between the students' ability. Furthermore, the differences in the mark distributions could be accounted for by unobserved characteristics and the skill sets of the 2009 students. For example, maths paper 3 was not compulsory in the 2008 NSC maths school leaving exam. Finally, it needs to be noted that the cut-off at 71% is not the value required to pass the economics June exam but merely to replicate the distribution of marks obtained from the 2008 student cohort that entered the university with Higher Grade maths marks.

Conclusion

Universities need reliable signals to select suitable student applicants into their programmes. Until now, school marks have been considered sufficient at conveying the applicant's ability to handle the workload and requirements of tertiary education. Our findings confirm that the former SC Higher Grade school maths marks are a good predictor of academic performance in commerce courses at the university level. Therefore, for universities to be able to identify and select suitable applicants it is crucial that the new NSC school maths mark functions equally well as an appropriate signal. However, the introduction of the NSC has created a structural break in this signal. This has created uncertainty among admissions offices and a significant number of students have been admitted into programmes without them being suitably equipped to handle the academic material.

In order to test the comparability of the two marking systems – SC Higher Grade versus NSC – we compare the performance of the 2008 first year commerce student cohort, which was admitted based on Higher Grade maths marks, with the performance of the 2009 first year commerce student cohort, which was admitted with the NSC maths marks. We use their test results for the first economics and computational maths test to predict the Higher Grade maths mark which a NSC matriculant would have achieved given his/her observable individual characteristics and apply propensity score matching to compare the signalling ability of the Higher Grade maths mark with the NSC maths mark. Our results show that the NSC maths marks of the 2008 matriculants do not sufficiently signal the numerical abilities (disabilities) of the students. The applied conversion between the former SC Higher Grade maths symbols and the new NSC maths marks as was applied during the 2009 intake is inflated by around 13%. Furthermore, the findings indicate that the NSC maths marks do not sufficiently discriminate between the abilities of students, but rather group students with substantially different abilities into a very narrow range of marks. Thus, NSC matriculants who achieved a mark between 70-100% have an academic ability similar to former SC matriculants who achieved 40% and more in Higher Grade maths. This confirms that the signal of ability given by the new NSC school leaving maths has weakened significantly.

Finally, the results suggest that only if the university had imposed an admissions requirement of around 71% (level 6) for NSC school maths would the 2009 cohort perform equivalently to the 2008 cohort. However, this is not the entry requirement associated with passing Economics 1, it merely would create a 2009 cohort with similar academic abilities as the 2008 cohort. This further illustrates that the set of skills which pupils gain in current school maths is inadequate for the requirements of commerce courses at tertiary level.

Currently, universities across South Africa have responded to this skills mismatch with various ad hoc short-term changes in their existing student support structures. However, our results imply a need for universities to make fundamental institutional changes to deal with these deep-rooted problems.

Appendix

Table 1A: Summary Statistics

Cohort	variable	Mean	Std.dev	Min	Max
	Age	19.428	0.679	17	23
	Male	0.474	0.500	0	1
	Black	0.435	0.496	0	1
	Coloured	0.031	0.173	0	1
	Indian	0.306	0.461	0	1
	white	0.228	0.420	0	1
	Home language	0.572	0.495	0	1
	Financial aid	0.093	0.291	0	1
	test0 (Comp Maths test)	66.100	19.600	0	100
	test1 (Economics Test)	46.427	14.727	13	96
	WITS_RESIDENT	0.158	0.366	0	1
2008	NSC_MATHS	.	.	.	.
	MATHS_HG	68.006	12.962	40	100
	MATHS_SG	78.556	10.877	60	100
	Free State	0.009	0.093	0	1
	Eastern Cape	0.028	0.166	0	1
	Gauteng	0.767	0.423	0	1
	Kwa Zulu Natal	0.093	0.291	0	1
	Limpopo	0.048	0.214	0	1
	Mpumalanga	0.024	0.153	0	1
	North west	0.024	0.153	0	1
	Northern cape	0.002	0.047	0	1
	Western Cape	0.004	0.060	0	1
2009	Age	18.627	0.623	16	22
	Male	0.452	0.498	0	1
	Black	0.596	0.491	0	1
	Coloured	0.034	0.180	0	1
	Indian	0.213	0.410	0	1
	white	0.158	0.365	0	1
	Home language	0.413	0.493	0	1
	Financial aid	0.127	0.333	0	1
	test0 (CompMaths test)	50.864	22.047	-15	100
	test1 (Economics Test)	35.445	15.429	1.66	95
	WITS_RESIDENT	0.136	0.343	0	1
	NSC_MATHS	73.748	11.836	49	100
	MATHS_HG	.	.	.	.
	MATHS_SG	.	.	.	.
	Free State	0.012	0.108	0	1
	Eastern Cape	0.028	0.164	0	1
	Gauteng	0.714	0.452	0	1

	Kwa Zulu Natal	0.100	0.300	0	1
	Limpopo	0.066	0.248	0	1
	Mpumalanga	0.035	0.185	0	1
	North west	0.043	0.204	0	1
	Northern cape	.	.	.	.
	Western Cape	0.003	0.051	0	1

Table 1 summary statistics (continued)

Cohort	variable	Mean	Std.dev	Min	Max
Full sample	Age	18.931	0.753	16	23
	Male	0.460	0.499	0	1
	Black	0.535	0.499	0	1
	Coloured	0.033	0.178	0	1
	Indian	0.249	0.432	0	1
	white	0.184	0.388	0	1
	Home language	0.473	0.499	0	1
	Financial aid	0.114	0.318	0	1
	test0 (CompMaths test)	56.653	22.401	-15	100
	test1 (Economics Test)	39.638	16.072	1.66	96
	WITS_RESIDENT	0.145	0.352	0	1
	NSC_MATHS	73.748	11.836	49	100
	MATHS_HG	68.006	12.962	40	100
	MATHS_SG	78.556	10.877	60	100
	Free State	0.011	0.103	0	1
	Eastern Cape	0.028	0.164	0	1
	Gauteng	0.734	0.442	0	1
	Kwa Zulu Natal	0.097	0.296	0	1
	Limpopo	0.059	0.235	0	1
	Mpumalanga	0.031	0.174	0	1
	North west	0.036	0.186	0	1
	Northern cape	0.002	0.047	0	1
	Western Cape	0.003	0.055	0	1

Table 2A: Regression results for Economics test 1 (various specifications)

	(1)	(2)	(3)	(4)
VARIABLES	MATHS_Higher Grade	MATHS_ Higher Grade	MATHS_ Higher Grade	MATHS_ Higher Grade
Test1 (Economics)	0.416***	0.296**	0.413***	0.249*
	(0.0292)	(0.125)	(0.0306)	(0.135)
Test1 squared		0.00122		0.00165
		(0.00121)		(0.00129)
English	0.373***	0.369***	0.376***	0.369***
	(0.0614)	(0.0618)	(0.0653)	(0.0654)
Male	1.373	1.345	0.878	0.847
	(0.881)	(0.883)	(0.910)	(0.909)
Home language (English)	2.141	2.249	2.349	2.527
	(1.640)	(1.668)	(1.694)	(1.738)
African	-1.816	-1.694	-1.902	-1.739
	(1.704)	(1.726)	(1.772)	(1.803)
Coloured	-7.686***	-7.627***	-7.855***	-7.764***
	(1.938)	(1.941)	(2.079)	(2.079)
Indian	0.815	0.827	0.444	0.444
	(1.147)	(1.147)	(1.204)	(1.206)
Free State			-0.774	-0.619
			(3.335)	(3.327)
Eastern Cape			-1.785	-1.867
			(2.863)	(2.799)
KwaZuluNatal			-1.181	-1.187
			(1.624)	(1.629)
Limpopo			1.454	1.433
			(2.206)	(2.217)
Mumpumalanga			-4.580**	-4.495**
			(2.299)	(2.271)
North West			1.038	1.069
			(3.366)	(3.342)
Northern Cape			6.879***	7.276***
			(0.997)	(1.085)
Western Cape			-3.366	-3.624
			(3.435)	(3.483)
Financial Aid	0.738	0.622	0.501	0.394
	(1.402)	(1.398)	(1.456)	(1.441)
WITS_RESIDENT	3.638***	3.732***	3.662**	3.828**
	(1.291)	(1.292)	(1.508)	(1.507)
test1_2		0.00122		0.00165
		(0.00121)		(0.00129)
Constant	18.13***	21.02***	18.50***	22.43***
	(4.638)	(5.558)	(4.934)	(5.889)
Observations	616	616	583	583
R-squared	0.440	0.441	0.453	0.454

Graph 1A – Actual and predicted maths mark distribution (non-linear with provinces)

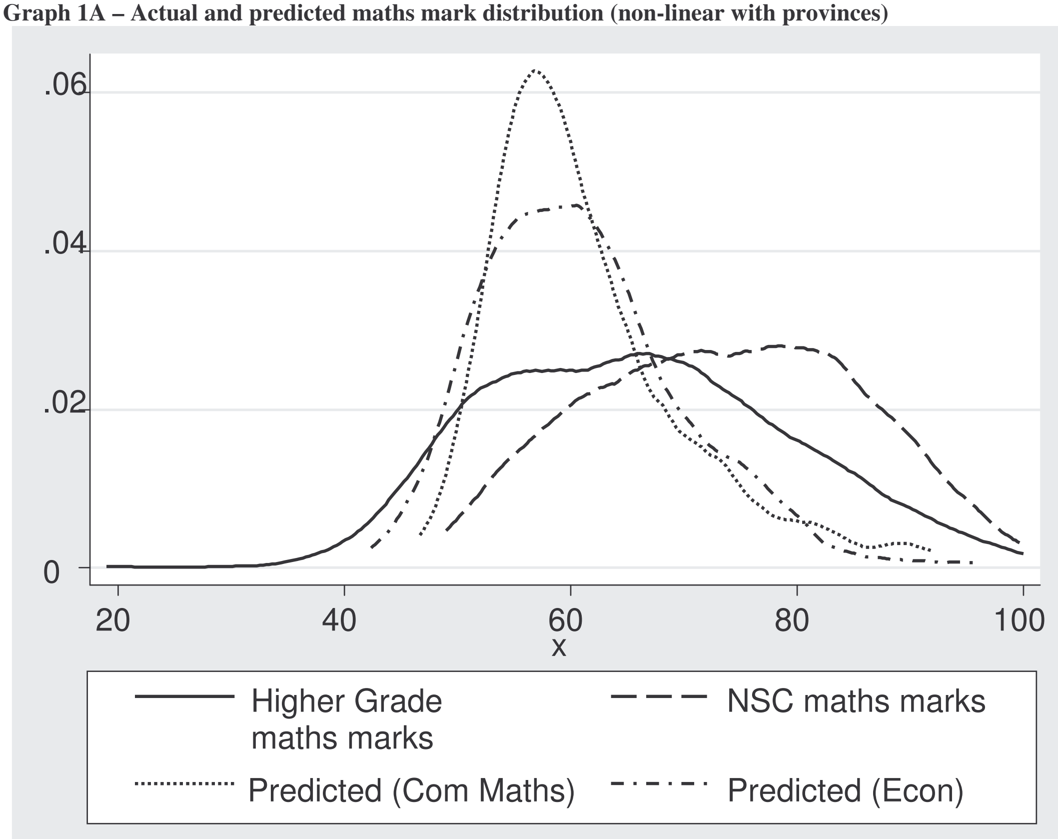


Table 3A: Propensity score matching (Average maths mark comparison)

Variable	Sample		NSC	Higher Grade	Difference	S.E.	T-stat
Maths	Comp Maths	|	73.52	60.61	12.91	1.23	10.46
	Economics 1	|	73.52	61.40	12.11	1.50	8.05

Note: S.E. for ATT does not take into account that the propensity score is estimated.

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