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ABSRACT

This article uses a logistic probability distribution approach to examine the effect of lecture attendance, aptitude test results, individual heterogeneity, and pedagogic intervention on student performance (pass rates) for first-year microeconomics and second-year macroeconomics modules at one of the leading South African universities. The research was motivated by the throughput concerns in South African institutions of higher education, where approximately one in four of the students enrolled complete their degrees in the minimum regulated time. Using secondary data of 630 and 360 first- and second-year students respectively, the findings revealed that lecture attendance, aptitude score and having received a foreign high school education have a positive and statistically significant effect on academic performance for both modules. Male students outperformed their female counterparts only at first-year level. Students who received intervention and those using English at home performed better than others at second-year level. Based on these findings, recommendations were made.

Key words: Academic performance, attendance, logistic regression, heterogeneity, pedagogic intervention.

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Biography

Phocenah Nyatanga is a lecturer of Quantitative Economics at the University of KwaZulu Natal. Her research interest includes consumer behavior, demand analysis and international development.

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Introduction

Student performance and throughput are on the decline in South Africa, regardless of the vast resources made available to the students, ostensibly to improve their performance.[1] According to the 2011/2012 annual report of the South African Council on Higher Education (CHE), only one in four students enrolled in contact higher education institutions complete their degrees in the minimum regulated time, 48% within five years, and 55% never graduate due to both academic and socio-economic factors. According to the South African labor force statistics, the national unemployment rate is estimated to be 25%, and only 5% of university graduate are unemployed, pointing to the fact that the labor market is in need of skilled workers. Thus, the low throughput, to a great extent, explains the shortage of a skilled workforce in the country, which is necessary for economic growth and development. It has therefore become a national challenge to enhance throughput and strengthen the quality of educational offerings and practices of higher education institutions (HEIs) in South Africa. In response to this challenge, the CHE launched a quality enhancement program in 2014, which focuses on improving teaching and learning, student success and capacity development. The goals of the CHE will be difficult to achieve unless better understanding of factors determining student performance, specifically in South African universities, is established.

Using first- and second-year data of students enrolled in the principles of microeconomics and macroeconomics modules at one of the leading universities in South Africa, the study seeks to predict the probability of a student passing these modules, taking into account lecture attendance, high school scholastic aptitude test (SAT) scores, individual heterogeneity, and pedagogic intervention. The two broad research questions this study seeks to answer are; What

[1] The term "throughput" in this paper refers to progression and the timely completion of degrees.

role do these variables play in determining whether a student passes or fails? and, what policy recommendations can be drawn from these findings to enhance throughput? To the best of the authors' knowledge, this study is the first in South Africa to collectively measure the controlled effects of these variables on student performance; hence shedding more light on the determinants of student performance for policy making.

The rest of the article is structured as follows: the next section reviews literature; followed by a discussion of the dataset and methodology; the paper then discusses the empirical findings, and lastly, concluding remarks.

Literature review

Several determinants of academic achievement have been identified and received considerable attention in scholarship. These include lecture attendance, SAT scores, English language proficiency, individual heterogeneity, pedagogic intervention in the form of bridging modules, quality of lectures, and socio-economic factors.[2]

a) Lecture attendance

Lecture attendance has been widely accepted to have a positive and statistically significant effect on student performance. Romer (1993), Durden and Ellis (1995), Chen and Lin (2008), as well as Horn et al (2011) found that there is a positive and statistically significant relationship between lecture attendance and academic performance. However, recent technological developments have changed the way the students currently learn. The recent use of eLearning at this university to disseminate lecture notes and other learning resources before or after each

[2] Due to data limitations, this study excludes from its analysis the impact of lecture quality and socio-economic variables on academic performance and leaves this to future research.

lecture, without a stringent lecture attendance policy in place, seems to have created an impression among students that nothing much is missed by not attending lectures and that they can always catch up at their own leisure. Studies on the importance of the traditional face-to-face lectures, in light of web-based learning resources, have come up with conflicting conclusions. Bennett and Maniar (2007) and Gysbers et al. (2011) concluded that online delivery of lecture notes does not only reduce lecture attendance, but also undermines performance. Williams et al. (2012) also found that students who substituted face-to-face lectures with online lecture recordings did not perform as well as those who attended lectures and used the online resources as a supplementary tool. Brotherton and Abowd (2004), however, found no significant difference in student performance between those who attended face-to-face lectures and those who relied on online resources alone.

b) Scholastic aptitude test scores

Numerous studies, among them Park and Kerr's (1990), Birch and Miller (2005), and Bokana and Tewari (2014), support the argument that there is a positive correlation between SAT scores and university academic performance. However, Vars and Bowen (1998) and Conard (2006) found a relatively weak relationship between the two. Horn et al. (2011) also observed that, though the SAT score is an important determinant of performance, there is no wide variation on its effect on the probability of passing at second year.

c) Pedagogic intervention

Academic intervention has been used by universities to enable students from academically and socially disadvantaged backgrounds with low SAT scores to achieve a higher education qualification. Vars and Bowen (1998), as well as Smith and Edwards (2007), using first year

data, found such intervention to have a positive impact on the academic performance of such students relative to the mainstream students. However, to be best of the authors' knowledge, little is known about the impact of such intervention on higher level modules.

d) individual heterogeneity,

The effect of gender, home language and whether one is an international or local student on academic performance were considered. Smith and Naylor (2001), as well as McKenzie and Schweitzer (2001), found females students to significantly outperform their male counterparts, a contradiction to Parker's (2006) findings that male students outperform their female counterparts. Snowball and Boughey (2012) further found that male students perform better at multiple-choice questions, while female students perform better at created response questions. Van der Merwe (2006) however found no gender difference in academic performance among economics students.

The same inconclusiveness applies to the effect of home language on academic performance. According to Parker (1996), as well as Smith and Edwards (2007), the use of English as a home language is positively related to academic performance. This finding was challenged by Gee (1990), Garcia and Pearson (1994), as well as Snowball and Boughey (2012) who found no difference in academic performance between those who use English at home and those who use other languages, especially where a multiple choice based assessment method was utilized.

In as far as the effect of being an international student has on academic performance is concerned, Li et al. (2010), using data from a Chinese university, found that international students, as well as Chinese students who had studied abroad, outperformed local students. The

authors attributed the international students' success to pressure of learning success by their families as well as superior English writing abilities. Rienties (2012), using data from five business schools in the Netherlands, found that international students with a western ethnic background perform better compared to those with a non-western background. However Mann et al. (2010) found that local students outperformed their international counterparts, and attributes it to cultural and psychological shock. Little is known about this in the African context.

Data set

This study, which is cross sectional in nature, used secondary data of all 630 first-year students and 360 second-year students who took the principles of microeconomics and intermediate macroeconomics modules, respectively, from February 2014 to June 2014.

a) Dependent variable

Academic performance is the dependent variable, and is categorical in nature, where 1 is assigned to students who passed these modules with 50% and above, and 0 if they failed. For both modules, results from three tests and a final examination, respectively accounting for 40% and 60% to the final mark, were used as the evaluation criteria for academic performance. Data on this variable were obtained from the university's official student records.[3]

b) Independent variable

Lecture attendance for each student was randomly tracked throughout the semester. Out of one double and two single weekly sessions, a sign in sheet was circulated randomly in one and

[3] Consent to use official student records data was obtained from the registrar's office. Students were also informed on data collected throughout the semester and their consent obtained.

sometimes two of the sessions (totaling thirty-two out of forty-eight lecture sessions), where students were asked to write their student number and signature in-front of enumerators, who would tally the signed sheets with a heard count to minimize the problem of students signing for their absent friends. It is important to note that lecture attendance is not mandatory and there is no penalty for not attending. To further explore the impact of attendance on performance, the attendance variable was transformed to a five categorical variable according to a 10% increment, with the below 50% attendance category being the reference category. This was done to determine the minimum attendance threshold a typical student should have to pass the modules.

To capture the effect of SAT scores on academic performance, the matriculation (matric) score was utilized. Heterogeneous variables used in this study are gender, language used at home (mother tongue), and educational background (foreign versus local,). Data on all these variables were obtained from the university's official student records.

For the effect of pedagogic intervention on academic performance, the performance of students in the mainstream program, a three year program, was compared to that of students in the Alternative Access Program (AAP), a four year program. The AAP, unlike the mainstream, offers students from academically disadvantaged backgrounds bridge modules and extra academic support to be able to compete with mainstream students. Thus, the intervention variable is categorical, with students belonging to the mainstream program being the reference category. Table 1 summarizes these variables. Table 2 present descriptive statistics of the data analyzed. The difference between first and second year percentages are defined by the less than (<) and greater than (>) signs.

Table 1. Definition of variables analyzed

Variables	Definition of variables
Performance	1 if student passed with a 50% or more, and 0 otherwise
Attendance	5 categories dummy variable : rank1 = if student attended less than 50% of the lectures (Base Category) : rank2 = student attended between 50 and 59% of the lectures : rank3 = student attended between 60 and 69% of the lectures : rank4 = student attended between 70 and 79% of the lectures : rank5 = student attended 80% and above of the lectures
Matric	Matriculation score
Language	1 if English is main language at home, and 0 if another language
Pedagogic intervention	1 if student belonged to the Alternative Access Program , and 0 if student belonged to the mainstream program
Male	1 if male, and 0 if female
Foreign	1 if student is foreign educated, and 0 if South African educated

Table 2. Descriptive statistics

Variables	1st-Year Students	Difference	2nd-Year Students
Class average grade (Percentage)	53.25	<	54.26
Percentage of student with a pass mark	66.03	<	73.89
Percentage of student with aless than 50% attendance record	32.06	<	42.54
Percentage of student with a 50% attendance record	8.25	<	12.39
Percentage of student with a 60% attendance record	20.32	>	11.55
Percentage of student with a 70% attendance record	17.14	>	14.93
Percentage of student with a 80%+ attendance record	22.22	>	18.59
Average matric score	32.2	>	30.59
Percentage of students in the AAP program	2.86	<	13.23
Percentage of students who are male	45.87	>	42.53
Percentage of students who had a foreign educational background	3.97	<	9.58
Percentage of students who use English as their home language	32.7	<	33.24

Note: i) The standard deviation for the class average grade at 1st and 2nd year is 16.26 and 12.36 respectively.
ii) The standard deviation for the average martric score at 1st and 2nd year is 7.76 and 10.66 respectively.

Data analysis

Taking into account that the dependent variable is categorical in nature, a logistic probability distribution model was adopted. While other studies have used ordinary least square (OLS) regression, this approach has been proven to be less ideal in analyzing dichotomous outcomes as

it violates one of the OLS regression assumptions that the variance of the error is constant for all independent variables (homoscedasticity). OLS also assumes constant marginal effects of independent variables on the dependent variable, and nothing constrains the OLS regression predicted probabilities to lie between 0 and 1 (Peng et al. 2002). The logit model is also advantageous compared to other models as it is less sensitive to outliers (Copas 1988). Our estimated conditional probability (p) of a student passing (Y), given the values of the independent variables (X_k) is expressed in (1) as:

$$p(Y = 1|X_k) = f(attendance, matric, male, foreign, language, pedagogic\ intervention) \quad (1)$$

where the marginal effect of X_k on Y varies as the value of X_k increases. The logit model is based on the cumulative logistic probability distribution and estimates the log of the odds that our outcome of interest, passing, would occur (Y=1). This is expressed in (2) as:

$$\pi = pr(Y = 1|X_k) = \frac{\exp(\alpha + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k)}{1 + \exp(\alpha + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k)} \quad (2)$$

where π ($0 \leq \pi \leq 1$) is the probability of the outcome of interest (passing) , α is the Y intercept, and the βs are the slope parameter to be estimated, measuring the effect of a unit change in the weighted log of the odds ratio of passing per unit increase in the Xs (dependent variables). Since the logit model is non-linear, equation (3) enables us to estimate the marginal effect of a particular predictor (X_k), on the probability that Y=1.

$$\ln\{odds(Y = 1|X_k)\} = 100(e^{\beta_k} - 1) \quad (3)$$

Discussion of regression results

Based on the results in Table 3, the coefficient for lecture attendance is positively related to performance, and statistically significant both at first- and second-year level, a finding consistent with Romer (1993), Stanca (2006) and Horn et al (2011). For first-year students, the odds of passing were 4.09 times higher for students whose attendance record was 60%, and increased by an additional 2.34 and 3.54 times for those who attended 70% and 80% of the lectures, respectively. For second-year students, the odds of passing were 1.63 times higher for students whose attendance record were 60%, and increased by an additional 1.89 and 1.77 times for those whose attendance record was 70% and 80% respectively. From these results it is concluded that the minimum attendance threshold to pass the first-year microeconomics module and second-year macroeconomics module is 60% and is 70% respectively. This finding is plausible given the complexity of higher level classes, which warrants a higher attendance frequency. With this in mind, more stringent lecture attendance policies or the right incentives need to be put in place to enhance student academic performance as proposed in Romer (1993) and Stanca (2006).

The matric score was found to have a positive and statistically significant effect on academic performance, both at first- and second-year (see Table 3). The average probability of a student with a matric score ranging from 30-34, 35-39 and 40-42 passing was 61%, 82%, and 92% respectively at first-year, and 74%, 81% and 85% respectively at second-year (see Table 4). However, students with a matric score of less than 30, all belonging to the AAP, outperformed those in the mainstream program at first- and second-year levels, irrespective of their low matric score (see the calculated probabilities in Table 4). What is important to note from these two results is that, while the matric score is an important predictor of academic performance, its importance is undermined by pedagogic interventions. Thus, institutions of higher learning

should not rely solely on SAT scores for university admission, but consider other factor in their recruitment processes, so that society is not deprived of potentially exceptional students who have the capacity, but less prior support, excel.

Table 3. Results of variables in the equation

Variable	1st-Year		2nd-Year	
	Coefficient	Odds Ratio	Coefficient	Odds Ratio
50% Attendance	0.167 [0.50]	1.18	0.069 [0.17]	1.07
60% Attendance	1.408*** [5.01]	4.09	0.487 [1.14]	1.63
70% Attendance	0.849*** [3.14]	2.34	0.639** [2.09]	1.89
80% Attendance	1.264*** [4.78]	3.54	0.57 [1.51]	1.77
Pedagogic intervention	0.953 [1.63]	2.6	1.213*** [2.65]	3.36
Matric	0.193*** [6.55]	1.213	0.092** [2.46]	1.1
Male	0.406** [2.15]	1.5	-0.171 [-0.65]	0.84
Foreign	6.37*** [5.95]	585.67	2.18** [2.19]	8.84
English language	0.257 [1.58]	1.293	0.645** [2.32]	1.91
constant	-6.651*** [-6.79]	0.001	-2.436887 [-1.90]	0.09
Likelihood Ratio (LR)	125.260		27.87	
Log likelihood	-344.457		-188.738	

Note: i) Numbers in square brackets [ ] are t ratios.
ii) **5% level of significance; ***1% level of significance

Table 4. Probability of passing

Variable	1st-Year Students	2nd-Year Students
	Probability of Passing	Probability of Passing
Local Student	0.632	0.703
Foreign Student	0.987	0.925
Mainstream Students	0.655	0.716
AAP Student	0.809	0.888
By Gender		
Female Students	0.626	0.757
Male Students	0.701	0.726
By Home Language		
Students using English at home	0.694	0.814
Students using non-English at home	0.646	0.705
By Matric Score Ranges		
30 -34	0.61	0.74
35 -39	0.82	0.81
40 - 42	0.92	0.85

Male students outperformed their female counterparts at first-year level, but not at second-year level (see Tables 3 and 4). This gender bias can be explained by the use of multiple-choice questions (MCQs) in all tests and examinations at first-year level, an assessment technique found to be more favorable to male than female students by Snowball and Boughey (2012), while at second-year level they are a combination of multiple-choice and created response questions, also known as 'open–ended' questions. On the basis of these findings, a more balanced form of assessment, with multiple-choice and open-ended questions, may need to be considered at the first-year level.

Students who use English as their home language outperformed those who use other languages, especially at second-year (see Tables 3 and 4). This can be attributed to the different forms of assessment used at first-year level (MCQs) and second-year level (both MCQs and

open-ended questions). The need to incorporating local languages and literacy skills in first-year mainstream programs, and not only as stand-alone programs, has recently been advocated by some local universities. Such a move is projected to improve understanding of the subject matter, which in turn is believed to improve student performance and throughput. However, it is too early to test such a hypothesis as this project is in its infant stage.

Students who received a foreign high school education performed better than students who received a local high school education, both at first and second-year level. Based on the calculated probabilities in Table 4, the probability of a foreign student passing was 98.7% and 92.5% at first- and second-year levels respectively, compared to 63.2% and 70.3% for a locally educated student at first- and second-year level respectively. [4] Based on this result, it can be inferred that, though the local high schools are producing students who meet the university program requirements, their ability to compete with their internationally educated counterparts is low. This inference is more plausible as it is in line with the Global Information Technology Report (World Economic Forum, 2013), which ranked the quality of South Africa's educational system, as well as its quality of mathematics and science education, at number 140 and 143 respectively, out of 144 countries in the study. Going by the findings of this study as well as the 2013 Global Information Technology Report, there may be a need for the Department of Education to take a relook at the high school curriculum with the aim of improving the quality of South African high school graduates, so as to ensure that locally educated students are more competitive with their international counterparts. The current quality enhancement project launched in 2014 by the CHE, which suggests improved teacher training, could be a solution to this problem, but this is also in its infant stages to assess its effectiveness.

[4] Though the sample of foreign students is small and their socio-economic characteristics was not factored in this analysis, the result is statistically significant and exceptional.

An evaluation of the regression's predictive ability was done to assess the goodness of fit of the model in predicting the probability of passing (see Table 5). For first-year students, the model correctly predicts 86.06% of the behavior of students who pass this module and 38.79% of those who fail. For second-year students, the model correctly predicts 98.5% of the behavior of students who pass this module and 10.64% of those who fail. These results confirm a relatively low rate of error and we therefore conclude that the model is better at predicting the students who will pass, than those who will not for both groups.

Table 5. Regression's predictive ability

	1st-Year Proportion Predicted			
Observed	Pass	Fail	Total	% Correct
Pass	358	131	489	86.06
Fail	58	83	141	38.79
Total	416	214	630	70

	2nd-Year Proportion Predicted			
Observed	Pass	Fail	Total	% Correct
Pass	262	84	346	98.5
Fail	4	10	14	10.64
Total	266	94	360	75.56

Conclusion

The study on which this article is based analyzed and compared student performance in first-year microeconomics and second-year macroeconomics modules at a leading university in South Africa. The aim was to evaluate the determinants of academic performance in these two modules. The main findings from this study were that lecture attendance and SAT scores are crucial determinants of student performance. However, pedagogical interventions were found to be more effective in enhancing performance for students with lower SAT scores from academically and socially disadvantaged backgrounds. Students with a foreign high school educational

background were found to outperform those with a local one. Also, students who use English as a home language were found to outperformance those who use other languages, especially for higher level modules. Male gender bias on academic performance was recorded at first year level but not at second year.

To improve on the probability of a student passing these modules and throughput, we recommend the adoption of a compulsory attendance policy in the mainstream program of at least 60% and 70% at first-year and second-year level respectively. Also, since pedagogical interventions play an important role in ensuring students pass these modules, the matric score should not be used as the sole criteria of acceptance into university. More educational opportunities and support needs to be extended to students who are from disadvantaged backgrounds, who do not meet the university entrance criteria, but have potential. Finally, there is need to ensure that the quality enhancement project put in place is made a priority so that local high schools produce students who are internationally competitive.

For future research, there is need to further interrogate the importance of local languages in addressing throughput concerns in South African institutions of higher education, especially for higher level modules. Further research is also needed to determine the reasons behind the disparity in performance between students who obtained their high school qualifications locally to those who obtained it abroad to ensure more effective policy formulation. Additional research is also needed to ascertain whether the SAT scores and other individual characteristics, which are statistically significant at first- and second-year, hold for higher and more complex modules.

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