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Studying the Graduate Record Examinations' Ability to Predict Student Success as Measured by Graduate Grade Point Averages

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Studying the Graduate Record Examinations' Ability to Predict Student
Success as Measured by Graduate Grade Point Averages

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Capstone in Public Administration
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Executive Summary

The Graduate Record Examination (GRE) is the most widely used graduate level admission test in the world, yet conflicts exist across the findings of many studies of the ability of the GRE to predict the success test takers will have as graduate students or in professional life. Additionally, most of the studies that exist on the GRE's ability to predict graduate student success use data from a previous version of the GRE that may not be applicable to the current version, thus rendering their use for policy making among makers of admission decisions limited and flawed. These studies also tend to focus on one specific degree program or type of degree, leaving no guidance for how the GRE might be useful for other programs.

In an attempt to provide a basis from which more comprehensive analyses can be modeled in the future, this quantitative study examines how well the three sections of the GRE predict success for graduate students at the University of Kentucky (UK), using the Graduate Grade Point Averages (GGPA) of 2,349 active graduate students in degree seeking programs as a measure of intermediate success, as is common practice in the literature. Two linear regressions are reported, one which includes only UK graduate students in non-STEM programs, and one which includes only UK graduate students in STEM programs. STEM or non-STEM is used to separate these students from one another because it allows an overall picture of how GREs might be useful for admission decisions at UK while still providing results that can be relevant to programs with key differences, as "the economic and social benefits of scientific thinking and STEM education are widely believed to have broad application for workers in both STEM and non-STEM occupations" (Gonzalez and Kuenzi 2012).

Results show that the three sections of the GRE General Test are predictors of success for non-STEM graduate students at UK, while two of the three (Verbal and Quantitative Reasoning) are predictors of success for STEM students. Further, the Verbal Reasoning section is a better predictor of

success for non-STEM students than for STEM students, while the Quantitative Reasoning section is a better predictor for STEM students than non-STEM students. The Analytical Reasoning section is found to predict success only for non-STEM students.

These findings do not evaluate whether GRE scores are the best way of predicting the success of graduate students, nor should they be used exclusively to make admission decisions for applicants to an academic program. Instead, it is recommended that GRE scores be used as a portion of a holistic review of such applications, a recommendation which the owners of the GRE also make. According to some of the literature, the GRE puts some minorities and women at a disadvantage for admission to graduate programs. With this in mind, other studies have found the undergraduate GPA of a student is the best predictor of how well they will do in a graduate program, thus it is recommended that programs considering revision of their policies concerning GRE requirements for admission offer waivers for students that have or exceed an undergraduate GPA they deem appropriate to succeed in their program in lieu of removing an existing requirement for the purposes of increasing diversity or attracting more students. Additionally, programs without GRE requirements should consider adding it to the list of what an applicant needs for admission (with or without waivers), as it provides a standardized score that can assist in gauging the cognitive abilities and potential successes of its takers. Lastly, programs that do have GRE requirements and are classified as STEM should place more emphasis on the Quantitative section of the GRE than the others, while non-STEM programs should do the opposite.

Introduction

Much like the ACT and SAT standardized tests are a major factor in a high school student's acceptance to various colleges and universities, the Graduate Record Examination General Test (GRE) is a major factor for admittance to many graduate programs across the United States.[1] This includes the

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[1] It should be noted that while this is the primary use and purpose of the GRE, it is also used for various other purposes, most notably, they are often included in applications for graduate fellowships and scholarships.

University of Kentucky (UK), where the majority of graduate programs require applicants to take the

GRE.[2] Despite this, many programs at institutions across the United States offer exceptions or waivers to

their requirement of GRE scores, and some don't require it at all.[3] These differences in requirements

between programs, coupled with a conflicting, outdated, and/or narrow base of literature on the subject

is an issue, because disagreement over the GRE's effectiveness as a measurement of future student

success leaves graduate admission teams with no real guidance to assist in shaping their policies

concerning the use of the test.

This study will estimate whether the GRE is an effective test, in the context of its predictability

of future student success as measured by the grade point averages (GPA) of current graduate students

at the University of Kentucky. The intention is not to just test the overall predictability of the three

exams within the GRE (Quantitative Reasoning, Verbal Reasoning, and Analytical Writing), but to

measure the predictability of each exam for students in programs recognized by the federal government

as being STEM (Science, Technology, Engineering, and Mathematics) programs, and those that are not.

There have been previous attempts to measure the effectiveness of the GRE before, such as a

research article published in early 2017 that determined the GRE was ineffective at predicting the

productivity of biomedical graduate students at the University of North Carolina at Chapel Hill (UNC),

among other findings.[4] Another study at Vanderbilt University, published the same day as the UNC

article, effectively mirrored those results.[5] However, other studies indicate that the GRE might be useful

at predicting success. For instance, a report published in June 2018 found that the GRE was a strong

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[2] While some programs, such as the Master of Public Administration (MPA) program at Eastern Kentucky University (EKU), provide a target or minimum score, others, such as the MPA program at the University of Kentucky (UK), simply require the GRE and process each application holistically.
[3] In addition to EKU's MPA program providing a target score for the GRE, they also provide waivers for students that have a GPA from their undergraduate studies of 3.0 or higher. UK's MPA program does not offer exceptions to the GRE requirement unless a student has taken another graduate examination required for one of their joint degree programs, while UK's Master of Science in Social Work does not require the GRE at all.
[4] (Hall, O'Connell and Cook 2017)
[5] (Moneta-Koehler, *et al.* 2017)

indicator of success for law students.[6] These and other studies are discussed more in the Literature Review section of this paper.

In addition to conflicting findings, the literature largely uses data from a previous iteration of the GRE to reach conclusions, which may not reflect its current potential as a measurement of future student success. Studies thus far have also primarily focused on one specific degree program for analysis. While the results might be useful for similar programs and areas of study, they do not evaluate the predictability of the GRE in a general sense. The programs examined in the literature are mostly in STEM fields, leaving an inability to generalize their results to non-STEM programs. Since this study not only analyzes students in STEM and non-STEM programs, but also uses the current iteration of the GRE to see how well its scores predicted their future success, the included analysis and discussion can be an important starting point for future, more variable-rich studies, even with its limitations. Still, given the conflicted, outdated, and narrow focused nature of the rest of the literature, it is clear that more research must be completed in order to fully evaluate if the GRE is an appropriate measure of the future success of the students that take it.

Literature Review

The Graduate Record Examinations (GRE) began as an experiment in 1937 by the Carnegie Foundation for the Advancement of Teaching.[7] In the aftermath of World War II, the Carnegie Foundation transferred control of the GRE to the newly created Educational Testing Service (ETS)[8], which is now the world's largest nonprofit educational measurement organization.[9] The GRE remains under the control of ETS, and according to their website is, "the world's most widely used admission test for graduate & professional school" (Educational Testing Service 2019a). Throughout its over 80 year

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[6] (Klieger, et al. 2018)
[7] (Rourke and Ingram 2004)
[8] (Rourke and Ingram 2004)
[9] (Bennett 2005)

existence the GRE has experienced several changes, of which the most significant to this study occurred in 2011, when ETS updated the GRE to be more adaptive, "where performance on the early sections determines the difficulty of later sections presented on the exam" (Buchy 2017).

The GRE General Test includes three sections – Verbal Reasoning, Quantitative Reasoning, and Analytical Writing. ETS provides a description of the abilities each section attempts to measure. They state that the Verbal Reasoning section measures the test taker's ability to:

- analyze and draw conclusions from discourse; reason from incomplete data; identify author's assumptions and/or perspective; understand multiple levels of meaning, such as literal, figurative and author's intent

- select important points; distinguish major from minor or relevant points; summarize text; understand the structure of a text

- understand the meanings of words, sentences and entire texts; understand relationships among words and among concepts (Educational Testing Service 2019b)

ETS states that the Quantitative Reasoning section of the GRE measures the test taker's ability to:

- understand, interpret and analyze quantitative information

- solve problems using mathematical models

- apply basic skills and elementary concepts of arithmetic, algebra, geometry and data analysis (Educational Testing Service 2019b)

ETS states that the third section, Analytical Writing, measures the test taker's ability to:

- articulate complex ideas clearly and effectively

- support ideas with relevant reasons and examples

- examine claims and accompanying evidence

- sustain a well-focused, coherent discussion

- control the elements of standard written English (Educational Testing Service 2019b)

The intent of the GRE is clear – to provide a standardized method of measuring the abilities students will likely need to use in graduate school, and to use those measurements to supplement the more subjective materials included in applications, such as resumes or letters of recommendation.

Through a quick examination of several university websites, it is clear that ETS's claim that the GRE is the most widely used test for admission to graduate and professional schools is likely true. The University of Kentucky's Graduate School includes the GRE General Test in its list of minimum requirements for admission, with exceptions depending on specific programs.[10] The University of Louisville (UofL),[11] Western Kentucky University (WKU),[12] Indiana University Bloomington (IU Bloomington),[13] and countless other schools across the United States have similar statements on their own websites. As the GRE is almost always required for graduate admissions to these universities, it is important to evaluate whether it is an effective tool at predicting the future success of the students that take it. While much research has already focused on doing just that, an examination of specific program requirements across schools demonstrates the need for more analyses.

One specific program that each of the aforementioned universities share is a Master of Public Administration or Master of Public Affairs (MPA). UK, UofL, WKU, and IU Bloomington all receive the same accreditation for their MPA programs from the Network of Schools of Public Policy, Affairs, and Administration (NASPAA),[14] yet researching the admission requirements for these programs yields different GRE requirements for each. UK's Martin School of Public Policy and Administration requires students entering one of its degree seeking programs[15] (including MPA) to take the GRE or Graduate Management Admissions Test (GMAT) unless they are pursuing a joint degree. The GRE requirement can

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[10] (University of Kentucky 2019a)

[11] (University of Louisville 2019a)

[12] (Western Kentucky University 2019a)

[13] (Indiana University Bloomington 2019a)

[14] (Network of Schools of Public Policy, Affairs, and Administration 2018)

[15] As of the completion of this paper, the Martin School at UK only offers graduate level coursework and degrees. This will not likely be the case in upcoming years.

be waived for students that take either the Law School Admission Test (LSAT) for a joint MPA/Juris

Doctor or Pharmacy College Admission Test (PCAT) for a joint MPA/Pharmacy Doctorate – students have

to be accepted into their joint program as well.[16] Meanwhile, UofL requires all students entering its MPA

program to take the GRE, even if they are pursuing a joint degree.[17] WKU typically requires entering

MPA students to take the GRE, but offers exceptions to applicants that either have a cumulative

undergraduate GPA (UGPA) of 3.0 or above (from an accredited institution), or 3 years of relevant

experience in the public sector.[18] Similar to UK, IU Bloomington's School of Public and Environmental

Affairs requires all its degree seeking students to take the GRE or either the GRE or LSAT if they are

pursuing a joint MPA/Juris Doctor, but does not allow the GMAT to be substituted for the GRE.[19]

This example shows that four geographically close schools with similar programs sharing the

same accreditation do not have the same requirements regarding GRE scores for admission. There have

been previous studies using differing research designs to attempt to measure the GRE's predictability of

future graduate student success, but this research has produced conflicting results. The studies that do

support the GRE as a good predictor of future student success still usually indicate that it should still be

used sparingly and as a part of a holistic approach, a practice which ETS also recommends.[20]

Additionally, most of the current literature, even post-2011 publications, use data from a previous

iteration of the GRE to reach their conclusions. Using an old iteration of the GRE to make policy

suggestions for programs that are recruiting students with the current version of the exam might fail on

external validity, as changes made to the structure of the exam could mean the previous predictability

of the GRE is no longer applicable for current use. This conflict and possible inapplicability could mean

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[16] (University of Kentucky 2019b)

[17] (University of Louisville 2019b)

[18] (Western Kentucky University 2019b)

[19] (Indiana University Bloomington 2019b)

[20] (Educational Testing Service 2018)

that the differences in program requirements are at least in part due to disagreements on how useful the GRE actually is.

Two recent research articles, one of which examined the University of North Carolina at Chapel Hill[21] and the other Vanderbilt University,[22] failed to reject the null hypothesis that the GRE was ineffective at predicting the productivity of biomedical graduate students in both schools.[23] The authors of the Vanderbilt article note that admission committees have relied heavily on using GRE scores to narrow their pool of applicants, at least for biomedical Ph.D. programs, despite ETS advising only a restrained use, as previously mentioned.[24] They go on to state that ETS's own studies have found only a slight correlation between GRE and graduate GPAs (GGPA), which the authors' results later support.[25] Despite this slight correlation, the authors also found that GRE scores do not predict a student's progress in their program or their research productivity in this study, and thus suggest that admission committees for biomedical Ph.D. programs should take a more holistic approach when reviewing potential students, removing much of the current emphasis on GRE scores – a point which the UNC article also makes.[26]

A study conducted by Casey Miller and Keivan Stassun in 2014[27] argues that, "De-emphasizing the GRE and augmenting admissions procedures with measures of other attributes — such as drive, diligence and the willingness to take scientific risks — would not only make graduate admissions more predictive of the ability to do well but would also increase diversity in STEM" (Miller and Stassun

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[21] (Hall, O'Connell and Cook 2017)

[22] (Moneta-Koehler, *et al.* 2017)

[23] Both these articles use pre-2011 GRE data, so the issues they outline may have been addressed in the GRE's revision.

[24] (Moneta-Koehler, *et al.* 2017)

[25] (Moneta-Koehler, *et al.* 2017)

[26] (Moneta-Koehler, *et al.* 2017); (Hall, O'Connell and Cook 2017)

[27] Despite being published in 2014, this study also uses evidence from pre-2011 GRE data.

2014).[28] The authors support this claim by showing that the Quantitative section of the GRE correlates

with gender and ethnicity in a way that puts women and minorities at disadvantages for admission to

graduate schools, especially in STEM programs. Specifically, and among other examples available

throughout the article, Miller and Stassun use data from ETS to show that, "women score 80 points

lower on average in the physical sciences than do men, and African Americans score 200 points below

white people" (Miller and Stassun 2014).

Conversely, a 2013 thesis[29] by a University of Nebraska-Lincoln (UNL) student found that the

GRE was a useful predictor for determining the GGPAs of engineering students.[30] Additionally, a report

published in June 2018[31] found that the GRE was a strong indicator of success for law students.[32]

However these studies, like the Vanderbilt and UNC articles, are still program specific; their results can

therefore not be generalized to students in other graduate programs. While the studies that provided

details of their samples had an adequate number of observations,[33] an analysis of all graduate students

regardless of program with post-2011 GRE scores and a GGPA above 0 (indicating they have completed

at least one course in a graduate program), such as the one provided in this study, might offer a more

holistic approach, leading to a better understanding of the GRE's relationship to all students' future

successes. The research question for this study is: How well does each GRE percentile score predict the

GPA of graduate students in STEM programs versus those in non-STEM programs? GGPA is an

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[28] Unfortunately for the reader, Miller and Stassun do not include how to measure drive, diligence, or the willingness to take scientific risks. None of these attributes would be particularly easy to measure with the documents typically included in a basic admission application. Perhaps interviewing applicants as a requirement of admission to a program would provide at least an opportunity to ask questions that might incite examples of these attributes, but the logistics of doing this might not be feasible for some applicants or programs.

[29] This thesis used pre-2011 GRE data for analysis.

[30] (Wang 2013)

[31] This study used data from the current iteration of the GRE General Test as well as data from the previous iteration.

[32] (Klieger, et al. 2018)

[33] The Vanderbilt article examined 683 biomedical students over a 9 year period, The UNC article examined 280 biomedical students over a 3 year period, the UNL article examined 1,083 engineering students over an 11 year period, and the Klieger, *et al.* article examined 1,587 law students over 1 academic year before the 2011 revision and one academic year after the revision.

intermediate measure of success often used in literature, much like medical measures can be used to evaluate treatments before the time required for long-term health improvement.

Data Collection & Preparation

For this study, I obtained information about hundreds of students across the University of Kentucky. The original dataset was created by UK's Institutional Research and Advanced Analytics (IRAA) team as a compilation of information pulled from electronic student records. The dataset is used by the Graduate School's Office of Finance, Funding, & Analytics to supplement other materials included in applications for competitive fellowships. The dataset updates once a day to include new students or remove old ones, and is easily downloadable for those with the permissions to do so.

Regarding ethical issues associated with the information included in the dataset – to protect the Family Educational Rights and Privacy Act (FERPA) rights of students, and to avoid any conflicts with or misrepresentation of the Graduate School's interests, the majority of information from the dataset (including all identifying characteristics) was deleted immediately following its download by the Associate Dean of the Office of Finance, Funding, & Analytics in the UK Graduate School. The remaining categories of student information (GPA, post-2011 GRE percentile scores,[34] primary major, admission category group, application status description, degree program type, progression classification during term, primary degree[35]) were then copied into a new file, and the initial download file was destroyed. This file was placed on a password protected flash drive and transferred from the Associate Dean to the author. Next, admission category group, application status description, degree program type, progression classification during term, and primary degree were used to filter out all students that were

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[34] As previously mentioned, ETS's revision of the GRE in 2011 to make it more adaptive was a significant change. Because of this, students included in the dataset with only GRE scores prior to the 2011 update were not included in the final data used for analysis in this study; however, if a student had scores prior to the 2011 update and scores after the update in the original dataset, they might still be included using only the newer scores, depending on the other criteria used to determine inclusion.

[35] A description of each of these categories can be found in **Appendix A.**

not in a graduate level degree seeking program. These students were deleted from the data file, as were

the categories themselves. The primary major for each student was then replaced with a dummy

variable to indicate the student is enrolled in either a non-STEM or STEM program.[36] Once this was

completed, the data were again copied into a new file and the previous file destroyed for extra

precaution. Students with a GGPA of 0 (indicating they have not yet earned any credits from courses)

were then removed from the data, as were those that did not have a post 2011 GRE percentile for each

of the three sections of the test, as ETS does allow test takers to take other versions of the GRE that do

not include all sections. The final dataset included only five variables across 2,349 observed students:

GGPA, post 2011 GRE percentiles (three total, one variable each for Quantitative Reasoning, Verbal

Reasoning, and Analytical Writing), and STEM or non-STEM program.

The University of Kentucky's Office of Research Integrity reviewed a protocol application

(Institutional Review Board (IRB) Number 48957) for this study prior to the download of the dataset and

determined that no IRB approval was required as the study would not pose a threat to the privacy of

human subjects. The IRB approved an exemption certification on March 29, 2019.

Research Question

The purpose of this quantitative study is to provide an answer to the following, previously

mentioned research question: how well does each GRE percentile score predict the GPA of graduate

students in STEM programs versus those in non-STEM programs? GGPA is used as an intermediate

measurement of success for this analysis, as is common practice. Additionally, the type of program a

student is enrolled in (STEM or non-STEM, as defined by the Department of Homeland Security) is

included to evaluate whether any one section of the GRE is more predictive than the others for STEM

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[36] STEM programs were identified by comparing the Kentucky Council on Postsecondary Education's (CPE) academic program inventory for UK (filtered by degree type to only include graduate programs) with the Department of Homeland Security's (DHS) 2012 revised list of STEM-designated degree programs. Programs were matched using Classification of Instructional Programs (CIP) codes.

versus non-STEM students. This study hypothesizes that each section of the GRE General Test predicts

the GGPA of a student, further, it hypothesizes that these predictabilities vary by GRE section for STEM

and non-STEM students. The hypothesis is that the GRE Quantitative Reasoning section better predicts

the GGPA of STEM students, while the Verbal Reasoning and Analytical Writing sections better predict

the GGPAs of non-STEM students.

Methodology and Summary Statistics

As most of the potential controlling variables for this dataset are excluded to protect the rights

of students and the interests of the UK Graduate School, the linear regression equation used to perform

this analysis contains few variables:

$$Y_s = \alpha + \beta_1 \text{GRE\_Q}_s + \beta_2 \text{GRE\_V}_s + \beta_3 \text{GRE\_A}_s + \varepsilon_s$$

Where Y is the grade point average of student s, α is a constant value, GRE_Q is the first explanatory

variable (Quantitative Reasoning GRE percentile), GRE_V is the second explanatory variable (Verbal

Reasoning GRE percentile), GRE_A is the third explanatory variable (Analytical Writing GRE percentile),

and ε is a residual error term. This equation is used twice, once for students that have a (binary) dummy

variable of 1 for STEM (indicating they are enrolled in a STEM program), and once for students that have

a dummy variable of 0 for STEM (indicating they are enrolled in a non-STEM program). Given that the

dependent variable (GGPA) is a value between 0 and 4, GRE percentiles are scaled from 0 to 1 (as

opposed to 0 to 100) to make results easier to interpret. Additionally, even though GGPA is scaled from

0 to 4, **Appendix B** shows that only 5% of the observed students have GGPAs below 3.1, and more than

one third have a 4.0 GGPA. This means the effective range for GGPAs is about 0.9 or less, thus even

though the coefficients throughout the results of the linear regressions in the Analysis & Findings section

seem small, their effects are not trivial.

Table 1 contains summary statistics of the GGPAs and GRE percentile scores analyzed, while

Table 2 contains the distribution of Non-STEM and STEM students across the 2,349 observed students.

Appendix C contains summary statistics for STEM versus non-STEM students. **Appendix D** contains a

Pearson's correlation of all five variables. All variables are correlated and statistically significant with the

exception of the Quantitative and Analytical Writing sections of the GRE. Being in a STEM program is

negatively correlated with GGPA and both the Verbal and Analytical Writing sections of the GRE are

highly positively correlated with the Quantitative section of the GRE.

Table 1: Summary Statistics

VARIABLE	OBS	MEAN	STD. DEV.	MIN	MAX
GRADUATE GPA (4 POINT SCALE)	2,349	3.74	0.33	1.25	4.0
GRE VERBAL REASONING	2,349	0.59 (59%)	0.25	0.01 (1%)	0.99 (99%)
GRE QUANTITATIVE REASONING	2,349	0.50 (50%)	0.26	0.01 (1%)	0.99 (99%)
GRE ANALYTICAL WRITING	2,349	0.52 (52%)	0.27	0.01 (1%)	0.99 (99%)

Table 2: STEM Distribution

	FREQ.	PERCENT
NON-STEM (0)	1,369	58.28
STEM (1)	980	41.72
TOTAL OBSERVATIONS	2,349	

Appendices E, F, and **G** contain graphs of the estimated density distribution of each section of

the GRE. Verbal Reasoning percentile scores are distributed in a near normal manner, but with a large

plateau from about the 50th to 90th percentiles. Quantitative Reasoning percentile scores are also

distributed in a near normal manner, albeit with less kurtosis than a normal distribution of density.

Analytical Writing percentile scores are distributed in a mountainous manner. This is likely because the

Analytical Writing section of the GRE General Test is scored on a different scale than the other two

sections. It is scored from 0 to 6 in half point increments. This small range means that while the possible

range of percentile scores remain the same for Analytical Writing as the other two sections (essentially 1

through 99), there are fewer percentiles within that range that are actually possible to achieve, which

effects the distribution of those percentiles.

Analysis & Findings

Interpreting the initial results provided by the Pearson's correlation presented in **Appendix D**, a

graduate student in a STEM program is associated with a lower GGPA. Potential explanations of this

include that STEM programs might be more difficult than non-STEM programs, that non-STEM students

are graded less harshly than STEM students, or that the metrics of grading often used in STEM programs

are more objective than those used in non-STEM programs, making it difficult for faculty members in

STEM programs to execute discretion while grading. Different observations may draw different

conclusions on this finding, and future research may prove interesting to faculty members and students

alike, but this finding is beyond the scope of this study.

When tested by themselves with a linear regression, each section of the GRE is found to predict

a higher GGPA for a given student with statistical significance when using a linear regression. **Appendix**

H combines the coefficients for each GRE section when regressed alone using GGPAs as the dependent

variable for both STEM and non-STEM students. However, an accurate test requires the utilization of the

equation provided in the Methodology and Summary Statistics section of this study.

Using this equation, when a linear regression is performed without including the STEM variable

the results shown in **Table 3** appear. This test shows a significant, positive relationship between the

Verbal and Analytical Writing sections of the GRE with GGPAs, but no statistically significant relationship

between the Quantitative section of the GRE and GGPAs. Specifically, the entire range of Verbal

Reasoning scores are associated with a 0.15 increase in GGPA (p-value < 0.001). Meanwhile, the entire

range of Analytical Writing scores are associated with a 0.13 increase in that student's GGPA (p-value <

0.001).

Table 3: Regression Results without STEM Inclusion

GRADUATE GPA	COEFFICIENT	ROBUST STD. ERROR	T-STATISTIC	P-VALUE
GRE VERBAL PERCENTILE	0.15	0.03	4.22	<0.001***
GRE QUANTITATIVE PERCENTILE	0.02	0.03	0.76	0.446
GRE ANALYTICAL WRITING PERCENTILE	0.13	0.03	4.18	<0.001***

2,349 Observations; R-Squared = 0.0404
*** indicates statistically significant at p < 0.001

Still, these results don't answer the research question this study asks. To do this, two

regressions must be completed using the same equation used above, where one includes only students

in STEM programs and the other includes only students in non-STEM programs. Comparing the

coefficients these regressions generate will test the hypotheses made in the Research Question section

of this paper concerning differences in the predictability of different sections of the GRE General Test for

non-STEM and STEM students. **Table 4** presents the results of a regression using only non-STEM

students, while **Table 5** includes the results of a regression using only STEM students. Analyzing the

outputs of these two tests, all three sections of the GRE General Test are able to predict the success of

non-STEM students with statistical significance, and all but the Analytical Writing section are able to

predict the success of STEM students with statistical significance. Specifically, the entire range of Verbal

Reasoning scores are associated with a 0.16 increase in GGPA for non-STEM students (p-value = 0.001)

and a 0.11 increase in GGPA for STEM students (p-value = 0.030). The entire range of Quantitative

Reasoning scores are associated with a 0.08 increase in GGPA for non-STEM students (p-value = 0.038)

and a 0.12 increase in GGPA for STEM students (p-value = 0.011). The entire range of Analytical Writing

scores are associated with a 0.14 increase in GGPA for non-STEM students (p-value = 0.001). Since the

Analytical Writing section of the GRE General Test has no statistical significance for STEM students at

UK, the null hypothesis that this section does not predict the success of STEM students is not rejected.

However, all other results are statistically significant, thus we can reject the null hypotheses for these

results and conclude that all sections of the GRE General Test are predictors of success for non-STEM

students at UK, and that the Verbal and Quantitative Reasoning sections of the GRE General Test are

predictors of success for STEM students at UK. Further, the predicted effect the Verbal Reasoning

section has on GGPA is higher for non-STEM students than it is STEM students, and the predicted effect

of the Quantitative Reasoning section is higher for STEM students than it is non-STEM students. While it

is a predictor of success for both types of students, the Verbal Reasoning section is a better predictor of

success for non-STEM students while the opposite is true for the Quantitative Reasoning section. The

predictability of the Analytical Writing section also varied in the way expected despite only having a

statistically significant effect for non-STEM students.

Table 4: Regression, Non-STEM students

GRADUATE GPA (NON-STEM)	COEFFICIENT	ROBUST STD. ERROR	T-STATISTIC	P-VALUE
GRE VERBAL PERCENTILE	0.16	0.05	3.44	0.001**
GRE QUANTITATIVE PERCENTILE	0.08	0.04	2.08	0.038*
GRE ANALYTICAL WRITING PERCENTILE	0.14	0.04	3.33	0.001**

1,369 Observations; R-Squared = 0.0553

** indicates statistically significant at p < 0.01, * indicates statistically significant at p < 0.05

Table 5: Regression, STEM students

GRADUATE GPA (STEM)	COEFFICIENT	ROBUST STD. ERROR	T-STATISTIC	P-VALUE
GRE VERBAL PERCENTILE	0.11	0.05	2.17	0.030*
GRE QUANTITATIVE PERCENTILE	0.12	0.05	2.55	0.011*
GRE ANALYTICAL WRITING PERCENTILE	0.05	0.05	1.06	0.291

980 Observations; R-Squared = 0.0231

* indicates statistically significant at p < 0.05

Limitations to Methodology

The primary limitation to this study is that it lacks the inclusion of several controlling variables

and factors that are normally present in the studies found in the literature. Due to concerns of student

privacy and the possibility of a misconception of the Office of Finance, Funding, & Analytics' intended

uses for the study's results, variables such as gender, race, age, ethnicity, and each student's specific

program were intentionally excluded, among other potential explanatory variables.[37] Additionally,

information used in similar studies as additional measurements of success were not available. For

instance, information such as degree completion, number of presentations and publications, and grant

and/or fellowship obtainment have been used in a similar study but was unobtainable in this case.[38] Low

R-squares for both regressions used for analysis indicate that the model does not capture the variance

of the data very well, thus while it can be determined that GRE scores are a predictor of GGPA for

students (with the exception of the Analytical Writing section for STEM students), they are not the best

predictor. The lack of the above and presence of low R-squares for the tests used in analysis indicate

serious concerns of the construct validity of this research design.

Another variable that is often included as an explanatory variable for GGPA is a student's UGPA

or GPA from a different graduate degree. The data from which variables included in this analysis were

drawn from did include a transfer GPA variable, however many students had nothing in this category.

Additionally, each datum for all students that did have something under this category was unreliable, as

for some students it represented an UGPA before they transferred to and completed their

undergraduate degree at UK before moving on to graduate school, while for others it represented a

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[37] Note, however, that gender, race, age, and ethnicity are demographic categories not used in admissions for well-understood reasons.

[38] (Moneta-Koehler, *et al.* 2017)

GGPA that was transferred to credits in their current program. There was no feasible way to compare these.

The parameters for inclusion in this study's analysis inherently led to a few examples of sample bias during data cleaning, where several areas of the sample were underrepresented for various reasons. Students studying in UK's Doctor of Medicine program were excluded from analysis because they are not graded using GPAs. Programs that do not require GRE scores for admission (whether or not another entrance exam is required) are not explicitly excluded from analysis, as some students in those programs may have taken the post-2011 GRE, but they were still underrepresented in the data. For programs that allow either the GRE or GMAT, students that chose to take only the GMAT were excluded. Students that did not take the post-2011 GRE for a different reason, such as obtaining a waiver, were excluded from the data. Students that have a GGPA listed as 0 in the data were excluded, as this indicates they have not yet completed a course and are unable to be analyzed.[39]

Perhaps the most prominent of sampling biases is that the population for which this study is attempting to measure, graduate students, is spread across the country. UK cannot reasonably be expected to be able to accurately represent such a large and diverse population, especially when not all graduate programs exist at every university. Because of this, the results may not be able to be generalized to other universities, adding concerns of external validity to this study. In contrast, internal validity for this study is quite high, as the sample presumably includes all non-Doctor of Medicine graduate students at UK that have both taken the GRE in recent years and completed a semester of their studies.

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[39] Generally, this means a student is in their first semester of enrollment or withdrew from any previously enrolled courses.

Conclusion & Recommendations

Through the analysis provided in the Analysis & Findings section, all sections of the GRE are good predictors of all UK graduate student's success (with the sole exception of Analytical Writing for STEM students). Further, Verbal Reasoning scores better predict the success of non-STEM students, while Quantitative Reasoning scores better predict the success of STEM students.

If a graduate program at the University of Kentucky has another source which they can use in conjunction with this study to base their decisions on GRE requirements for admission, a few recommendations can be made. First, it is recommended that all graduate programs adopt, if they have not already, some sort of requirement for the GRE.

Some of the literature mentions that GRE scores have the possibility to put minorities and women at a disadvantage for admission to graduate programs. Conversely, some articles, such as a 2018 article on Inside Higher Ed by David Payne,[40] have cited implicit bias as a reason to place more emphasis on GREs, but if they are as good a predictor of race and gender as Miller and Stassun claim, it seems there is no way to win. Some of the literature notes that undergraduate GPAs are an excellent measure of a students' future success in a graduate program, thus it is recommended programs offer waivers to students that meet a certain undergraduate GPA requirement, which could reduce the possibility of placing women and minorities at a disadvantage in regards to the bias the GRE contains. Such waivers would also make programs look more attractive to students that have an aversion to the GRE or standardized testing in general, or that can't afford to pay ETS to take the GRE. Unfortunately, tackling the implicit bias present in admission decision making is beyond the scope of this study.

Another recommendation that can be made is that for the emphasis that is be placed on GREs, programs considered STEM should place their focus on only the Verbal and Quantitative Reasoning scores, while non-STEM programs should put more of their attention toward Verbal Reasoning and

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[40] (Payne 2018)

Analytical Writing, but not dismissing the Quantitative Reasoning section altogether. Still, no cut-off should be used, but following this method would ensure that program administrators will have a basic grasp of the relevant abilities of a student in relation to the coursework they would be required to complete.

Areas for Future Study

The structure of this study is intended to be used as an example for which future studies may be modeled, thus the first recommendation for future studies is that they include more variables for control and analysis, including more measures of success.

The second recommendation for future studies is that they utilize GRE scores from only the current version of the GRE in their analysis. Without doing so, any study that uses pre 2011 GRE data is already outdated, as its results may not be applicable to the current version of the test. Without this applicability, policy recommendations will be flawed as they will be based on a test that isn't given to the incoming students that programs are making their decisions about.

The third recommendation for future studies is that data from many graduate programs at multiple universities across several geographic and demographic areas with varying other characteristics be obtained for analysis. Without data from multiple sources, it is difficult to support the claim that findings can be generalized to other universities, as some schools may have unique characteristics that set them apart from others. Obtaining data from a wide range of graduate programs across a wide-range of universities will help the external validity of any future study.

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Appendixes

Appendix A: Category Descriptions

CATEGORY	DESCRIPTION
GPA	A student's cumulative GPA at their current level of study
POST-2011 GRE PERCENTILE SCORES	Three separate categories (Verbal Reasoning, Quantitative Reasoning and Analytic Writing)
PRIMARY MAJOR	The specific degree program a student is studying for (Public Administration, Chemistry, etc.)
ADMISSION CATEGORY GROUP	What type of admission a student was last granted (undergraduate freshman, readmit, etc.)
APPLICATION STATUS DESCRIPTION	Indicates if a student is planned or active
DEGREE PROGRAM TYPE	Shows what type of degree a student is enrolled in (undergraduate, law, medicine, etc.)
PROGRESSION CLASSIFICATION DURING TERM	Indicates the level of degree progression a student is currently at (Graduate – Master's, Graduate – Doctoral, etc.)
PRIMARY DEGREE	The level of degree a student is studying for (Master of Arts, Master of Science, etc.)

Appendix B: GPA Detailed Summary Statistics

	PERCENTILES	SMALLEST		
1%	2.6	1.25	Observations	2,349
5%	3.1	1.667		
10%	3.333	1.667	Mean	3.738
25%	3.6	1.667	Std. Dev.	0.328
50%	3.846	**LARGEST**		
75%	4.0	4.0	Variance	0.107
90%	4.0	4.0	Skewness	-2.032
95%	4.0	4.0	Kurtosis	9.537
99%	4.0	4.0		

Appendix C: Summary Statistics for STEM v. Non-STEM Students

VARIABLE	OBS	MEAN	STD. DEV.	MIN	MAX
GRADUATE GPA NON-STEM	1,369	3.774	0.321	1.25	4.0
GRE VERBAL NON-STEM	1,369	0.609	0.244	0.01	0.99
GRE QUANTITATIVE NON-STEM	1,369	0.394	0.224	0.01	0.98
GRE ANALYTICAL NON-STEM	1,369	0.577	0.268	0.01	0.99
GRADUATE GPA STEM	980	3.689	0.330	1.667	4.0
GRE VERBAL STEM	980	0.570	0.256	0.01	0.99
GRE QUANTITATIVE STEM	980	0.652	0.232	0.01	0.99
GRE ANALYTICAL STEM	980	0.445	0.275	0.01	0.99

Appendix D: Pearson's Correlation

	GGPA	GRE_V	GRE_Q	GRE_A	STEM
GGPA	1				
GRE_V	0.1807***	1			
GRE_Q	0.0421*	0.2331***	1		
GRE_A	0.1762***	0.5848***	0.0011	1	
STEM	-0.1282***	-0.0786***	0.4876***	-0.2334***	1

*** indicates statistically significant at $p < 0.001$, * indicates statistically significant at $p < 0.05$
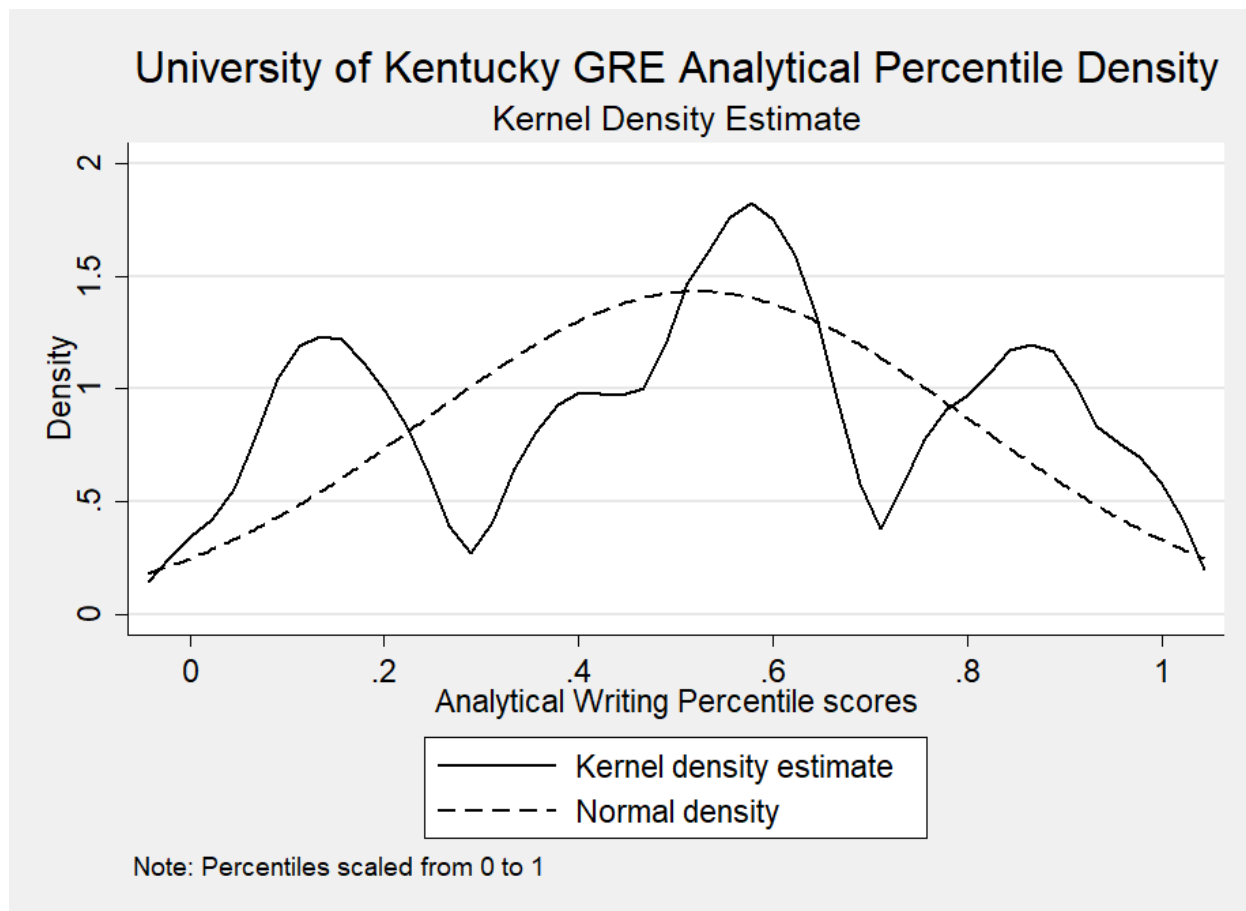
Appendix E: Density of GRE Verbal Percentile Scores

University of Kentucky GRE Verbal Percentile Density — Kernel Density Estimate
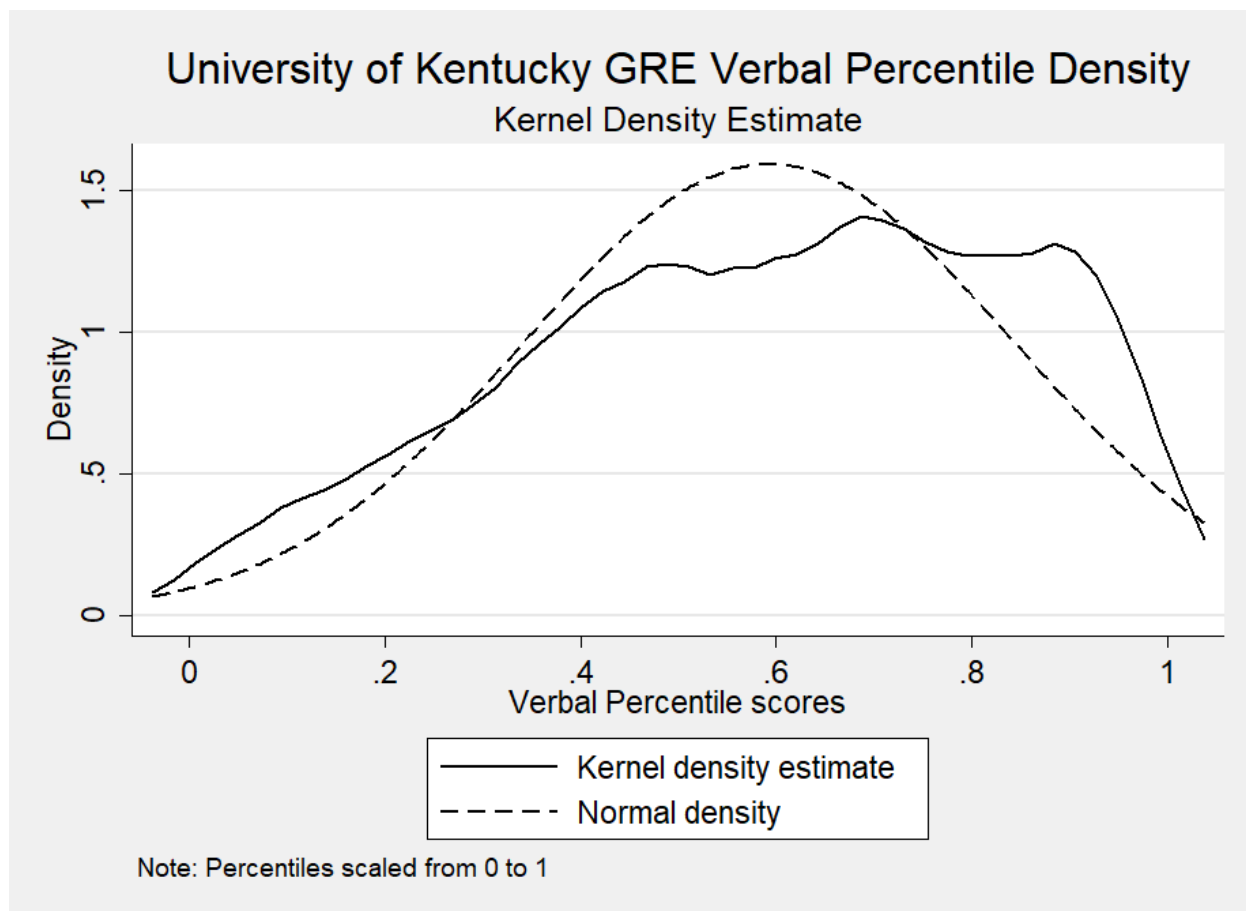
Appendix F: Density of GRE Quantitative Percentile Scores

University of Kentucky GRE Quantitative Percentile Density
Kernel Density Estimate

Note: Percentiles scaled from 0 to 1
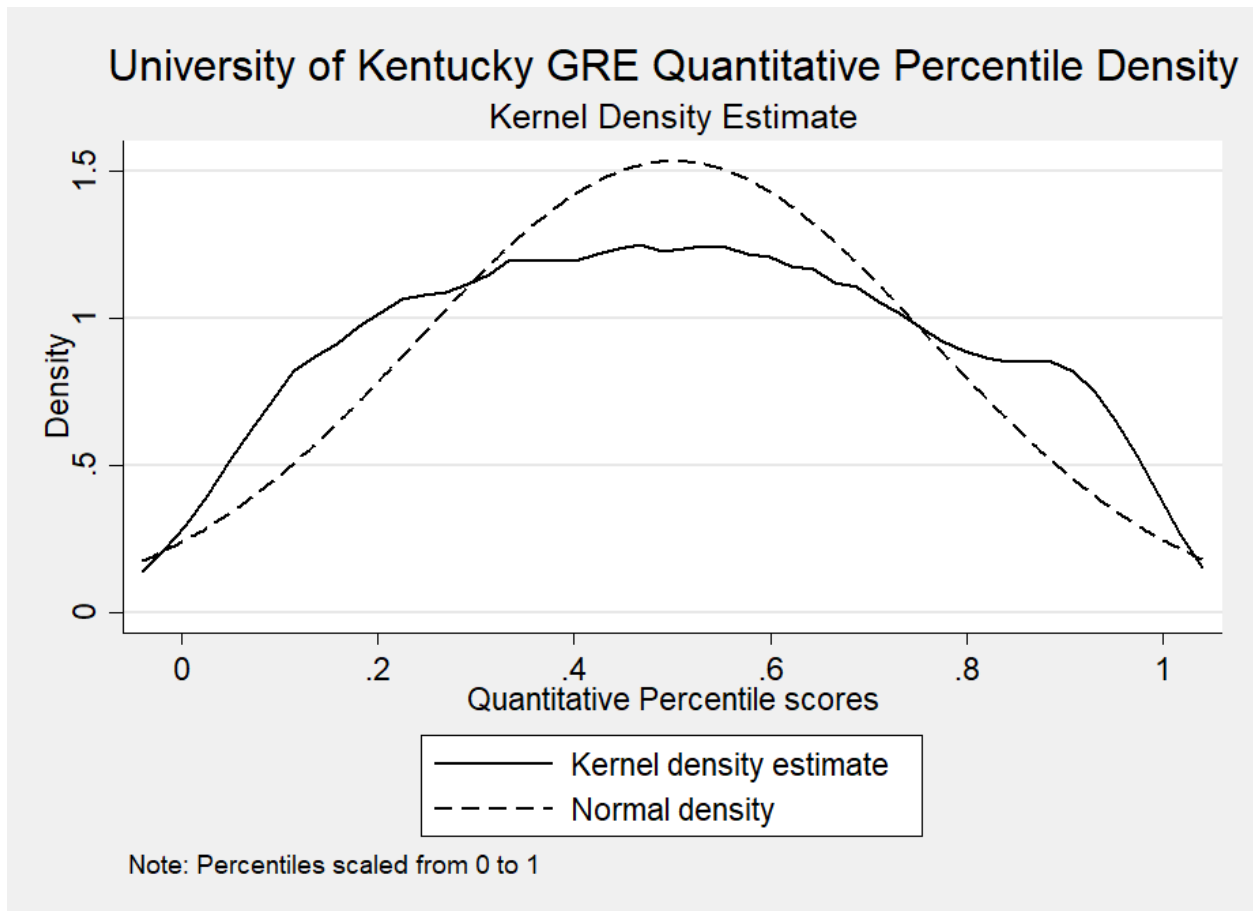
Appendix G: Density of GRE Analytical Writing Percentile Scores

Appendix H: Combined Individual Regression Results

GRADUATE GPA	COEFFICIENT	ROBUST STD. ERROR	T-STATISTIC	P-VALUE
GRE VERBAL NON-STEM	0.27	0.03	8.18	<0.001***
GRE QUANTITATIVE NON-STEM	0.20	0.04	5.44	<0.001***
GRE ANALYTICAL NON-STEM	0.23	0.03	7.4	<0.001***
GRE VERBAL STEM	0.16	0.04	4.02	<0.001***
GRE QUANTITATIVE STEM	0.14	0.05	2.96	0.003**
GRE ANALYTICAL STEM	0.12	0.04	2.95	0.003**

*** indicates statistically significant at $p < 0.001$, ** indicates statistically significant at $p < 0.01$