Does Math Proficiency Determine Performance in Introductory Finance Courses: Preliminary International Evidence

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Ⅰ Introduction

An understanding of the key factors which determine student performance in core business subjects should help faculty improve on their existing curriculum as well as provide instructors insight on how to better design their courses. Proficiency in arithmetic and mathematics is often cited as one of those factors essential for learning in core introductory courses such as finance and economics. The mounting evidence from recent research suggests that elementary mathematics and arithmetic are key elements in determining student performance in introductory finance courses in colleges in North America. However, to what extent does this relationship hold in an international setting. This study empirically investigates the relationship between math skills and student performance in an introductory finance course taught in English at a Japanese university. The current paper also contributes to the literature by examining the impact of customized math pre-test scores on academic performance in principles courses.

Cooley and Heck (1996) in a survey of finance faculty in the United States find the topics and concepts covered in "much detail" by 80% or more of the surveyed instructors require competence in quantitative or computational skills. These financial concepts include net present value, internal rate of return, and the valuing of stocks and bonds. Similar content is covered in courses worldwide thus warranting a closer look at whether math proficiency determines student performance in an international context. In the allied fields of economics and accounting, empirical research indicates mathematics skills are an important factor in predicting student performance in principles courses (Hafer and Hafer, 2002; Ballard and Johnson, 2004; Yunker, Yunker, and Krull, 2009; Hoag and Benedict, 2010). The finance education literature as surveyed by Akimov, Kobinger, and Malin (2017) provides us with a broad range of factors which are thought to predict performance in finance courses. Empirical research which examine the relationship between proficiency in mathematics and academic performance in introductory finance courses include Ely and Hittle (1990), Didia and Hasnat (1998), Pritchard, Romeo, and Saccucci (2000), and Raehsler, Hung, Yang, Stuhldreher (2012). The findings in finance are mixed. Ely and Hittle (1990) find little empirical evidence of a positive relationship course work in mathematics in secondary school and performance in a college level principles finance course. Didia and Hasnat (1998) and Raehsler et al. (2012), on the other hand, use the grades obtained in prerequisite college math courses as measures of proficiency in mathematics and find strong performance in perquisite math courses has a positive impact on performance in an in-

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troductory financial management class. Closer in spirit to the current study are Rich (2006) who employ the quantitative section of SAT scores and Pritchard et al. (2000) which uses a standardized test administered by the state of New Jersey to measure proficiency in math. As to be expected, their study provides empirical evidence that computational skills have a positive impact on performance in finance courses. While standardized tests and prior course work could gauge proficiency in arithmetic and mathematics, a customized pre-test covering topics most often encountered in principles courses should serve as a better measure of the required computational skills necessary to do well in a principles course. To this end, we employ a customized math pre-test in line with the economics and accounting literature (Yunker et al., 2009; Ballard and Johnson, 2004).

Ⅱ Data

Data is collected for an introductory finance course titled *Financial Management* in the Fall term 2018 and 2019 taught by the author of the current paper. The course is offered at an all English international liberal arts program in a recognized private university located in central Tokyo which we will refer to as WU. The course is offered as an elective where prerequisites in economics and accounting are not required. Recent work shows that English language proficiency plays an important role in determining academic performance when there is a substantial number of non-native English speakers in the class (Thompson, Aizawa, Curle, Rose, 2019). However, in this particular case, we do not control for language ability since English proficiency is exceptionally strong as evidenced by an average self-reported TOEFL iBT score of 99 for non-native English speaking students. Course enrollment in *Financial Management* at WU Fall 2018 was 88 and 90 in the Fall of 2019. Information for the explanatory variables was obtained from a survey and math pre-test taken in the third week of class. After omitting incomplete observations due to surveys with missing information and for students who did not participate in the survey itself, the sample size for our data set is 61 for 2018 and 67 for 2019. Students consented to the use of the data in aggregate form for this study by signing and dating the math pre-test and basic information sheet.

Student performance is measured as the score on a comprehensive final test administered on the last day of class in January. The final test is a closed note and closed book exam with a mix of multiple choice and short answer problems. The score for this final test (*FINAL*) is measured as a percentage (ratio) out of 60 total points. The descriptive statistics for the collected data is summarized in Table 1.

We administered a 12 question math pre-test as an index for math proficiency (*MATH*).

TABLE 1　SUMMARY OF DESCRIPTIVE STATISTICS

	FINAL	*MATH*	*GPA*	*STAT*
MEAN	0.691	0.775	3.108	3.067
MEDIAN	0.716	0.807	3.215	3.00
STANDARD DEVIATION	0.154	0.175	0.559	0.914
MAXIMUM	0.968	1.00	3.83	4.00
MINIMUM	0.172	0.154	1.00	1.00
OBSERVATIONS	128	128	128	128

MATH is measured as the ratio of correct answers out of twelve. The math test was tested in a pilot study with students in BT 183 *Finance*, an equivalent introductory finance course, offered in the college of business at Rikkyo University in Spring 2018. The pilot study allowed us to revise the wording of the questions and content of the pre-test. While some studies use standardized test scores such as the quantitative section of the SAT or ACT, these tests do not necessarily focus on the quantitative skills required in finance. The math pre-test used in this study covers basic algebra relevant to the study of finance including ratios, factoring, graphing a straight line, averages, and summation. The level and content of the questions are consistent with the math quizzes provided in the appendices in Yunker et al. (2009) and Ballard and Johnson (2004).

Many students find portfolio theory to be technically challenging especially at the introductory level as it involves the use of statistics. Unfortunately, in many cases, college students are not always exposed to the concepts covered in probability and statistics. The basics of location and spread statistics associated with a distribution and covariance are reviewed in the *Financial Management* course, however, an understanding of these topics beforehand should enhance learning. It follows that as a second variable to gauge mathematical proficiency, we include self-reported grades in introductory college statistics, *STAT*. The use of a variable such as *STAT* is needed to capture the relevance of statistics since standardized tests such as the ACT and SAT do not cover these quantitative skills. Hafer and Hafer (2002) use enrollment in a statistics course as an explanatory dummy variable. This dummy variable could proxy for familiarity with statistics but it does not necessarily gauge proficiency. Therefore, the statistics grade variable, *STAT*, employed in this study not only serves as a proxy for knowledge but for proficiency in the subject matter. *STAT* takes on a discrete value ranging from 1 to 4 reflecting the grade point earned in the course. The WU liberal arts curriculum is unique in that all students are required to pass a statistics class prior to graduating thus enabling us to readily obtain information from the surveyed students.

Finally, we collected information on self-reported *GPA* (grade point average) and study hours (*HRS*) to control for the effects of student effort. An important contribution of this study is the use of weekly study hours in the previous term to measure overall student effort. Didia and Hasnat (1998) employ study hours per week for the finance course in question and Nofsinger (1999) uses a 5 point scale of self-reported study hours one week prior to the exam. In contrast to these studies, we are interested in capturing overall student effort and general study habits as opposed to the effort dedicated to the finance course itself. Therefore, we asked students to provide information on the amount of time they spent on studies on average per week in the previous term. In the current study, *HRS* is a dummy variable ranging from one to four based on self-reported information (1= zero to 5 hours, 2 = 6 to 10 hours, 3 = 11 to 15 hours, and 4 = 16 hours or more). 28.1% of the class reported a "1," 45.3% reported a "2," 21.1% reported a "3," and finally 5.5% reported a "4." This classification of study hours is designed to be consistent with survey data collected and reported in 2008 by the Center for Research on University Management and Policy (CRUMP), Tokyo University <http://ump.p.u-tokyo.ac.jp/crump/cat77/cat82/post-6.html>. Note the students enrolled in this class spend more time studying and preparing for class than their counterpart surveyed at other Japanese universities. The Tokyo University survey of representative universities find that only one third of the students surveyed studied 6 or more hours a week in Japan.

Ⅲ Estimated Model and Results

We regressed the final test score for the course, *FINAL*, on four explanatory variables.

$$FINAL_i = \beta_0 + \beta_{MATH}MATH_i + \beta_{HRS}HRS_i + \beta_{GPA}GPA_i + \beta_{STAT}STAT_i + \varepsilon_i \quad (1)$$

where *MATH* is the score on the math pre-test, *HRS* is the dummy for the self-reported hours of study per week, *GPA* is the self-reported *GPA*, *STAT* is the self-reported statistics course grade, and ε is the error term for the *i*th student. We expect the coefficients on all four explanatory variables to be positive. The correlations between the explanatory variables reported in Table 2 below is not sizable indicating multicollinearity for individual variables should not be an issue when estimating the model.

Related studies in finance use an ordered probit model since the dependent variable is a grade point equivalent of a letter grade. In this study, the dependent variable is a test score in percentage form so we employ ordinary least squares (OLS) to estimate the regression model. The estimated coefficients are presented in Table 3. All four coefficients on the explanatory variables are positive and statistically significant at conventional levels. We find *GPA* is an important determinant consistent with the studies by Didia and Hasnat (1998), Sen, Joyce, Farrell, and Toutant (1997), Van Ness, Van Ness, and Kamery (1999), Nofsinger (1999) and Raehsler et al. (2012). Also, consistent with Hafer and Hafer (2002) is the importance of a statistics course as can be discerned by the statistically significant coefficient for *STAT*. Finally, our estimated coefficient for *HRS* is positive and statistically significant confirming the notion that study habits on a weekly basis is a crucial factor for performance in courses such as finance, economics. Thus, coupled with Didia and Hasnat (1998) findings that hours for a particular course are statistically significant, our results suggest the importance of study habits especially for building block type subjects such as finance.

TABLE 2 CORRELATION

	FINAL	*MATH*	*HRS*	*GPA*
MATH	0.489			
HRS	0.161	-0.042		
GPA	0.437	0.223	0.070	
STAT	0.491	0.427	0.085	0.602

Finally, the positive and statistically significant coefficient on *MATH* clearly indicates the importance of mathematics skills in the study of introductory finance. The impact measured as an elasticity evaluated at the mean is approximately 0.36 (=0.321 (0.775/0.691)). Thus a 10% percent increase in *MATH* should correspond to a 3.2% increase on *FINAL*.

Regression model (1) is tested for heteroskedasticity using the Breusch-Pagan test where the squared residuals are regressed on the explanatory variables and a constant. The F test statistic for this regression is 1.083 (null hypothesis all coefficients are zero) and the coefficients on each of the explanatory variables are not statistically significant. As a consequence, we do not correct the standard errors for regression model (1). We also conducted a Ramsey RESET to check for potential problems arising from model specification. The F statistic using squared and cubed fitted values (RESET) is 0.808 and not statistically significant.

A second regression model (2) is estimated with an expanded data set to include the exchange students who do not have a WU GPA and WU students who did not include their GPA or statistics grade in the survey. This increases the sample size to 153 out of a possible

TABLE 3 ESTIMATES FOR REGRESSION MODEL (1)

VARIABLE	COEFFICIENT	t-statistic (p-value)
CONSTANT	0.093	1.188 (0.237)
MATH	0.321	4.538 (0.000)
HRS	0.026	1.982 (0.049)
GPA	0.065	2.604 (0.000)
STAT	0.030	1.815 (0.072)
OBSERVATIONS	128	
ADJUSTED R^2	0.373	
RAMSEY RESET		0.808 (0.448)
BREUSCH-PAGAN		1.083 (0.368)

Ramsey RESET for squared and cubed fitted values (F-statistic). Breusch-Pagan test for heteroskedasticity (F-statistic)

178. *FINAL* is then regressed on measures of math proficiency, *MATH*, and student effort, *HRS*.

$$FINAL_i = \alpha_0 + \alpha_{MATH} MATH_i + \alpha_{HRS} HRS_i + \epsilon_i \quad (2)$$

The findings for regression model (2) are summarized in Table 4 and qualitatively similar to the results for regression model (1) in Table 3. The results in Table 4 not only confirms the robustness of our estimates for model (1) but illustrates the relevance of the two explanatory variables *MATH* and *HRS* which are unique to this study. The estimated regression models could be interpreted within the framework of a production function in economics, however, this study has the more modest objective of simply examining the relationship between math skills and performance in a finance course.

Ⅳ Concluding Remarks

This study provides preliminary empirical evidence indicating math skills play an important role in determining student performance in an introductory finance course. While the empirical results are both statistically and practically significant we acknowledge the fact that these results must be interpreted with care since three of the explanatory variables are based on self-reported information. Moreover, we are cognizant of the fact that factors such as self-efficacy could shed light on the behavioral implications of our findings for the math pre-test variable (Hackett and Betz, 1989). The objective of this paper, however, is to simply document the direct effect of the math pre-test on academic performance in finance so we treat the math pre-test score as an exogeneous variable. Nevertheless, the findings suggest the use of a customized math pre-test is appropriate for assessing math proficiency since the test covers topics and concepts most often used in a principles class. As a consequence, the outcome on a math pre-test administered at an early stage of the course can help us assess whether extra tutorial sessions in the second of the half of the course is warranted. Furthermore, a curriculum which includes prerequisite courses in statistics or quantitative methods should provide students with the appropriate tools to better comprehend the material covered in an introductory finance course.

TABLE 4 ESTIMATES FOR REGRESSION MODEL (2)

VARIABLE	COEFFICIENT	t-statistic (p-value)
CONSTANT	0.288	5.154 (0.000)
MATH	0.433	7.083 (0.000)
HRS	0.034	2.765 (0.066)
OBSERVATIONS	153	
ADJUSTED R^2	0.260	

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