Does High School Mathematics Improve Student Learning in Economics in the University?

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Abstract: The primary objective of this paper is to identify the importance of prior skill and knowledge of mathematics in influencing performance of students in introductory first year level economics subjects using data from a regional university in Australia. The study results have identified positive and significant relationships between the two factors. Results of this study are similar to some others in the area. However, this study is based on a more appropriate and sophisticated analytical model (Ordered Probit Model) as compared to OLS model used in the other studies. Findings of this analysis also suggest that the level of mathematics taken prior to university have a strong predictive power on students' performance. The findings have strong implications for learning and teaching practices in first year level subjects and on student retention rates for the Australian universities in general.

Keywords: Australia, Skill, Learning, Ordered Probit Model

Introduction

SINCE VERY EARLY days, quantitative skills have been considered as important for success in economics subjects in the university (Schoeffler, 1956). In general, knowledge and skills in mathematics enables a student to follow the logical sequence in a better manner. Primary contents in standard economics subjects being very systematic and logical the relationship between prior mathematics skill and performance in economics subjects in the university appears to be obvious. Several studies in recent years have re-emphasized the relationship using data from universities across the world (Mallik and Varua, 2008; Lagerlof and Seltzer, 2007; Birch and Miller, 2006; Ballard and Johnson, 2004). However, universities in several countries mathematics is not a prerequisite for admission into a degree that involves economics subjects. As a result, students without required skills often struggle in first year levels subjects. This impact on their level of motivation and increases the chance of drop outs from that subject as well as from the course.

In addition to prior knowledge and skill in mathematics, performances of students in first year level subjects are also found to be influenced by overall achievements in final school leaving exams (e.g. UAI in the state of NSW in Australia) (see, Nolan and Ahmad-Esfahani, 2007; Birch and Miller, 2006; Camara and Echternacht, 2000) and a number of other factors such as class attendance, method of teaching, socio-economic background, gender etc. (Cohn and Johnson, 2006; Lassibille and Gomez, 2008; Anderson et al., 1994; Barnes et al., 2005).

The primary objective of this paper is to identify the importance of prior skill and knowledge of mathematics in influencing performance of students in introductory first year level economics classes using data from a regional university in Australia. In the process, other

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identified factors are also considered in order to establish the relative importance of mathematics. Similar studies are extremely limited in Australia and they were entirely focussed on universities from metropolitan cities (Mallik and Varua, 2008; Birch and Miller, 2006). It is necessary to assess the situation for other locations in Australia, particularly in regional areas where socio-economic background of students could be very different from the same in metropolitan cities.

Data and Methodology

This study is based on information collected from Charles Sturt University (CSU), Australia. CSU campuses are mainly located in three regional towns in the state of New South Wales. Unlike city-based universities, large majority of CSU students are from regional areas with different socio-economic backgrounds. Although CSU is a provider of distance mode education, sample of students for this research includes only on-campus face-to-face mode students in order to maintain consistency with other research in this field. The data was collected from internal databases of CSU. Information on high school final exam performances such as UAI score, percentile scores in different subjects, and demographic information such as gender and age of individual students were collected from the computerised students' records. Information of grades achieved in first year economics subjects for the period 2004 to 2007 were collected from the CSU examination office.

Much of the literature in economics education used production function models in their analysis, with learning being treated as an output produced by such inputs as aptitude and courses taken (Anderson et al., 1994). Several studies in the US, where grades are awarded rather than marks, have used Tobit and Probit models (Jensen and Owen, 2003; Dancer and Fiebig, 2004). Linear regression analysis using Ordinary Least Squares methods (OLS) is also used to quantify the marginal learning effects of certain inputs.

This study used the Ordered Probit method for analysis as it is the most appropriate one in this case. Ordinary Least Square cannot estimate the parameters efficiently when dependent variables are ordered. Ordered Probit is a much parsimonious and sensitive model that takes account of the ordering of the dependent variable.

It is being conceptualised in this research that students' performances in first year level economics subjects depend on prior skills and knowledge such as proficiency in subjects like mathematics and economics and overall performance at high school final examination, and also on demographic factors such as gender and age. Being located in the state of New South Wales, large majority of the students in the sample were from the same state. In NSW school education system, students are allowed to choose subjects as per their requirements and abilities. Mathematics subject is offered at four levels, ranked as per the level of difficulty – General Mathematics, 2 unit Mathematics, Mathematics Extension 1 and Mathematics Extension 2. It is expected that students with better numerical and quantitative skills would go for higher difficulty level mathematics subjects. Overall performance of a student is measured in terms of University Admission Index (UAI) score, a percentile measure of relative performance.

We hypothesised that gender, UAI, marks (percentile scores) obtained by students in HSC in economics and different levels of mathematics subjects would be significant variables in explaining overall performance in first year level economics subjects. The relationship can be expressed as follows:

$$Ugrade_{ij} = \beta_1 + \beta_2 Gender + \beta_3 Age_i + \beta_4 UAI_i + \beta_5 ECON_i + \beta_6 GM_i + \beta_7 MATH_i + \beta_8 MATHone_i + \beta_9 MATHtwo_i + \varepsilon_i \text{ ---------(i)}$$

where:

Ugrade $_{ij}$ = the grade of ith individual for jth subject taught in the University. i=1,2,----n and j=1 (first year microeconomics), 2 (first year macroeconomics) and 3 (first year micro and macroeconomics combined).
Grade ranges between 0 to 4 where, 0= fail (below 50%), 1=pass (50% to 64%), 2=credit (65% to 74%), 3=distinction (75% to 84%), 4= high distinction (85% and above) obtained in the subject.
Gender $_i$ = dummy variable for gender - 1 for male and 0 for female.
Age $_i$ = age of the student as on May 2008.
UAI $_i$ = University Admission Index, constructed using the weighted average of all the percentile scores obtained by the students in the HSC exam.
ECON $_i$ = percentile score of two unit economics in HSC examination.
GM $_i$ =percentile score of general mathematics in HSC examination
MATH $_i$ =percentile score of 2 unit mathematics in HSC examination
MATHone $_i$ =percentile score of mathematics Extension one in HSC examination
MATHtwo $_i$ =percentile score of mathematics Extension two in HSC examination
e_i =random error term

Analysis of Results

The estimated coefficients of the determinants of economics subject grades (Ugrade as in equation (i)) using Ordered Probit model are presented in Table 1. It is apparent from the estimated coefficients that gender and age had no significant effect on economics subject grades. UAI had positive and highly significant effect on all economics grades. Prior skill and knowledge in HSC Economics subjects had limited impact on performances of the same subject at the university. The coefficients were significant in two models for combined data and at 5 per cent level of significance. It should be noted that the co-efficient of the economics unit was significant when higher level of mathematics, e.g. Extension 1 and Extension 2 were included in the model. It implies that prior knowledge of economics may have better predictive power with good prior knowledge of advanced mathematics. Interestingly, coefficients for General Mathematics were found to be consistently negative but significant in all models. This indicates that better performance in school level General Mathematics subject in fact reduces chance of performing better in economics subjects at the university level. This is possibly due to low level of difficulty in General Mathematics subject which fails to generate necessary logical skill required to study economics units in the university among the students. As expected, the coefficients for 2 unit Mathematics were consistently positive and highly significant for all models. It clearly indicates that higher level of mathematics at schools generates necessary quantitative skill and in turn, leads to better performance in economics subjects at the university. Also the value of coefficient was higher in case of microeconomics grades than others. Microeconomics generally includes more quantitative elements than macroeconomics and it had been correctly reflected in the result. Mathematics

Extension 1 also had similar impacts on economics subject grades. However, we do not want to emphasise much on this indicator as the number of students in this subject were relatively low. We did not consider Mathematics Extension 2 for individual economics subjects as sample sizes were small. However, we did consider it in the combined model and found the coefficient positive and significant at 5 per cent level. The co-efficient was more than four times higher than HSC economics subjects. It re-emphasised the fact that higher level of skill in mathematics helps students in performing better in university level economics subjects.

Table 1: Estimated Coefficients of the Determinants of Success in First Year Economics Subjects using Ordered Probit Model (Dependent Variable=Ugrade)

Variable	**Microeconomics**			**Macroeconomics**			**Micro and Macroeconomics combined**			
Gender	-0.168 (-0.74)	-0.245 (-1.08)	-0.195 (-0.87)	-0.151 (-0.66)	-0.167 (-0.73)	-0.212 (-0.93)	-0.157 (-0.99)	-0.198 (-1.25)	-0.198 (-1.26)	-0.142 (-0.90)
Age	-0.060 (-1.20)	-0.031 (-0.62)	-0.026 (-0.53)	-0.001 (-0.00)	0.010 (0.13)	0.036 (0.46)	-0.034 (-0.84)	-0.015 (-0.37)	-0.002 (-0.05)	-0.011 (-0.27)
UAI	0.049*** (5.41)	0.045*** (4.88)	0.048*** (5.30)	0.032*** (3.45)	0.029*** (3.09)	0.033*** (3.49)	0.041*** (6.39)	0.037*** (5.76)	0.040*** (6.36)	0.042*** (6.57)
Econ	-0.001 (-0.16)	-0.001 (-0.14)	0.006 (1.52)	0.003 (0.87)	0.003 (0.89)	0.007* (1.81)	0.001 (0.53)	0.001 (0.54)	0.005** (2.32)	0.005** (2.17)
GM	-0.013*** (-3.74)	-----	-----	-0.008** (-2.53)	-----	-----	-0.010*** (-4.59)	-----		-----
Math	-----	0.016*** (4.41)	-----	-----	0.009*** (2.76)	-----		0.012*** (5.00)		-----
Math-one	-----	-----	0.033*** (3.46)	-----		0.018** (2.02)			0.025*** (3.51)	-----
Matht-wo										0.022** (2.35)
Unit							0.006 (0.04)		0.023 (0.15)	0.012 (0.08)
N	109	109	109	103	103	103	212	212	212	212

Pseudo R^2	0.187	0.200	0.169	0.088	0.093	0.073	0.133	0.140	0.116	0.103
LR $\chi^2(5)$	51.62	54.01	46.61	22.80	24.04	18.71	71.23	75.22	62.46	55.28
Prob. of χ^2-stat	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000
Note: * , ** and *** implies significant at 10%, 5% and 1% respectively,										

Conclusions and Recommendations

The significance of high school level mathematics as a predictor of success in higher education, especially in the economics discipline, has important policy implications. It is clear from this research that 2 unit mathematics, mathematics extension 1 and extension 2 are found to be important determinants of students' success in the first year level economics subjects at the university. On the other hand, general mathematics has negative impact on economics subject grades. High school level economics skill had very limited role in the success in the university, even in the same subject. Results of this study are similar to some others in the area. However, this study is based on a more appropriate and sophisticated analytical model (Ordered Probit Model) as compared to OLS model used in the other studies. Thus, results of this study should have stronger implications. Findings of this analysis also suggest that the level of mathematics taken prior to university have a strong predictive power on students' performance. At the same time, the standard of General Mathematics subject in high schools needs to be improved and students should be encouraged to undertake at least 2 unit mathematics at high schools if they intend to pursue a career in economics related subjects.

References

Anderson, G., Benjamin, D. and Fuss, M. A. 1994. The determinants of success in university introductory economics courses, *The Journal of Economic Education*, 25(2): 99-119.

Barnes, G., McInerney, D. M. and Marsh, H. W. 2005. Exploring Sex Differences in Science Enrolment Intentions: An Application of the General Model of Academic Choice, *The Australian Educational Researcher* 32(2): 1-24.

Ballard, C.L. and Johnson, M. F. 2004, Basic Math Skills and Performance in an Introductory Economics Class, *Journal of Economic Education*, 35 (1): 3-23.

Birch, E.R. and Miller, P. W. 2006, Student outcomes at university in Australia: A quantile regression approach, *Australian Economic Papers*, 45(1): 1-17.

Camara, W.J. and Echternacht, G., 2000, The SAT I and High School Grades: Utility in Predicting in College, The College Board Research Notes. The College Board, Office of Research and Development, available at: *http://www.collegeboard.com/research/abstract/3869.html,*accessed November 2007.

Cohn, E. and Johnson, E. 2006, Class attendance and performance in Principles of Economics, *Education Economics*,14(2): 211-33.

Dancer, D. and Fiebig, D. 2004, Modelling Students at Risk. Australian Economic Papers 43, 158-173.

Jensen, E.J. and Owen, A. L. 2003, Appealing to good students in introductory Economics, *Journal of Economic Education,* 34(4): 299-325.

Lagerlof, J.N.M. and Seltzer, A. J. 2007, The Effects of Remedial Mathematics on the Learning of Economics: A Natural Experiment, available at *http://ssrn.com/abstract=1004458*, accessed November 2007.

Lassibille, G. and Gomez, L. N. 2008, Why do higher education students drop out? Evidence from Spain, *Education Economics* 16(1), 89-105.

Mallik G, Varua M (2008) "HSC Mathematics results and Tertiary success in Quantitative units: an Australian experience", *Australasian Journal of Economic Education*. 5(1-2): pp 1-10.

Nolan, E. and F.Z. Ahmadi-Esfahani, 2007, Predicting Performance in Undergraduate Agricultural Economics, The Australian Journal of Agricultural and Resource Economics 51, 1-15.

Schoeffler, S., 1956. Mathematics in economics: some dangers, The Review of Economics and Statistics 38(1), 88- 90.

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