The Journal of Economic Education
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/vece20

The Case of Effort Variables in Student Performance

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Published online: 10 Jul 2014.

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Economic educators acknowledge that students with diverse academic abilities respond differently to various instructional techniques (Allison 1976; Bonello et al. 1980; Cox 1974; Emery and Enger 1972; Kelley 1972). The difference is often so pronounced that the effect of a particular educational experiment may be insignificant for the overall sample of students but may have a significant effect for a subgroup. In spite of this knowledge, researchers estimate educational production functions for the entire population of students, and often get insignificant results for important variables.

This is especially true of student effort. Numerous studies have examined the relationship between the amount of effort a student puts into a principles of economics course and his or her performance in that course. Most of the studies, however, show that effort has no significant effect on performance, measured either by grades or scores on the Test of Understanding of College Economics (Allison 1982; Becker and Salemi 1977; Manahan 1983; Siegfried and Fels 1979).

One exception is a study by Robert M. Schmidt (1983) that found that the total time students devoted to the principles of macroeconomics course had no significant effect. However, when the time variable was disaggregated into components, the time spent in lectures, in discussion sections, and in studying for the second exam did have significant positive effects on the final exam scores. Time spent studying outside of class, however, had no significant effect, and time spent studying for the final exam had a negative and significant effect on the students' scores.

Schmidt believes that his findings reflect different productivities of studying techniques. When one aggregates the various techniques, the insignificant or negative effects of some (such as cramming for the final exam) mask the positive significant effects of other forms, making the overall study time insignificant.

Schmidt's research explains why studies that group all students together often show no significant effect from effort variables. High-ability students have good study habits that lead to positive effects, but low-ability students

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have poor study habits, such as cramming, that lead to negative effects. Thus, the overall effect for the total sample is insignificant.

This implies that there is a structural shift between above- and below-average students in the econometric models that explain principles of economics grades. If such a shift exists, and the two groups are estimated together, then the model is misspecified and the parameter estimates and their standard errors are biased. In this study we tested the existence of a structural shift. When we identified a structural shift, we estimated separate models for above- and below-average students.

DATA AND METHODOLOGY

In our study, we used the methodology of the educational production function. Grade in the course was used as a proxy for the output of economic knowledge, and the inputs were proxies of student ability and effort, as well as various demographic attributes (such as age and race) that may systematically affect the production function.[1] We used an ordered probit model to specify the production function because the dependent variable (grade in the course) was discrete (Becker 1983; McKelvey and Zavoina 1975; Spector and Mazzeo 1980).[2] We estimated three separate probit equations—one for the overall sample of students and one each for the above-average and below-average ability students, as measured by their ACT or SAT scores.[3]

The data came from students who took the principles of macroeconomics course at the University of North Florida (UNF), fall 1987. The two sections of the class were taught by the same instructor and consisted of 96 and 99 students.

Most of the data were obtained from the students' official records. The effort variables, however, were obtained from a survey students answered near the end of the semester but before taking the final exam. Because transfer students are not required to have SAT or ACT scores, the size of the sample was reduced to 116 students. This represented about 60 percent of the students who completed the course.

THE EMPIRICAL MODEL AND THE ESTIMATED RESULTS

The empirical model was of the following form:

GRADE = *f*(ENTGPA, ACTSAT, CUMHRS, CURLOAD, STUDYHRS, JCTRANS, RACE, SEX, AGE)

where

GRADE = the letter grade (A, B, C, D, F) the student received in the course, with A = 4, . . . , F = 0

ENTGPA = the grade point average (scale 0–4.0) of the student when he/she first entered UNF (either high school or other college).

ACTSAT	= 1 if ACT > 22.98 or SAT > 1004; 0 otherwise
CUMHRS	= the total credit hours the student had accumulated when he/she began the economics class.
CURLOAD	= the total number of credit hours the student completed the semester he/she took the economics class.
STUDYHRS	= the number of hours per week the student spent studying economics outside of class.
JCTRANS	= 1 if student transferred to UNF from a junior college; 0 if not
RACE	= 1 if nonwhite; 0 if white
SEX	= 1 if female; 0 if male
AGE	= age of the student at the time he/she took the course

The results of the probit analysis, estimated with a maximum likelihood estimation technique, are presented in Table 1. The three models included the same independent variables except for the ACTSAT variable, which was omitted from the second and third models because it had a value of zero for every observation in the second model and a value of one for every observation in the third model. In addition, the race variable had to be eliminated from the second model because it had a value of zero for every observation.

Using the total sample, we tested for the possibility of a structual shift between above- and below-average students by including an interaction term between each independent variable and the ACTSAT variable in the probit equation. The ratio of the log of the likelihood function of the probit equation with the interaction terms to the log of the likelihood function of the probit equation without the interaction terms followed a chi-square distribution and was used to test for the structural shift. Because the null hypothesis that the models are not different was rejected at the .005 level of significance, we estimated the two groups separately.[4]

The results of the probit analysis indicated how misleading it would be for students to base their academic behavior on the coefficient estimates from the total sample. According to that model, students can improve their chances of earning a good grade by accumulating more course hours before taking economics, but not by studying more because the effect of more study hours was insignificant. These conclusions, however, are completely wrong for a student with an above-average ACT or SAT score. According to the above-average student model, more hours accumulated had no effect on course grade, and more study time had a positive and significant effect.

It would be equally misleading for economic educators to base their policies on the results from the total sample. For example, according to those results, advisers should be concerned about placing freshmen or junior college transfers in the principles of macroeconomics course. When we estimated the models separately, however, we discovered that the concerns are warranted for below-average students but not for above-average.

From a research standpoint, the most striking change occurred in the effort variable when the models were estimated separately. Study time was in-

TABLE 1
Estimated Models of Principles of Economics Grades
Dependent Variable: Course Grade

Independent variable	All students (N = 116)	Above-average students (n = 73)	Below-average students (n = 43)
	Estimated coefficients		
CONSTANT	-1.822	-2.810	-11.394
	(-1.351)	(-1.592)	(-2.898)***
ENTGPA	0.902	0.832	1.491
	(4.068)***	(3.069)***	(3.307)***
ACTSAT	0.441		
	(1.866)*		
CUMHRS	0.013	0.003	0.018
	(2.229)**	(0.422)	(1.693)*
CURLOAD	-0.013	0.095	-0.008
	(-0.106)	(0.889)	(-0.078)
STUDYHRS	0.030	0.113	-0.127
	(0.759)	(1.713)*	(-1.605)
JCTRANS	-0.879	-0.664	-2.489
	(-1.750)*	(-0.931)	(-2.676)***
RACE	-0.260		-0.244
	(-0.704)		(-0.626)
SEX	-0.274	-0.560	0.211
	(-1.327)	(-2.057)**	(0.547)
AGE	0.034	0.008	0.455
	(0.817)	(0.154)	(2.606)***
χ^2	32.758	15.560	30.003
df	9	7	8
Critical value (5% level of significance)	16.92	14.07	15.51

Notes: t statistics are given in parentheses. They follow an asymptotically normal distribution. The chi-square statistic was used for a joint test of significance for all the coefficients except for the constant term.

*Statistically significant at the 10 percent level.
**Statistically significant at the 5 percent level.
***Statistically significant at the 1 percent level.

significant in the overall model, but it was positive and significant in the above-average model and negative and almost significant in the below-average model. These results are consistent with Schmidt's findings that some forms of studying have negative productivities. Evidently, below-average students have a tendency to use study techniques that are detrimental to learning economics. The policy implication is that below-average students should change their study techniques.

For example, Allen Kelley's TIPS study (1972) showed that below-average students benefited more from frequent homework assignments than did students with higher abilities. Bonello, Davisson, and Swartz (1980) found that lower-ability students gained more from computer-assisted instruction (CAI) than other students did. These results suggest that study techniques designed specifically to benefit below-average students should be emphasized in economic curricula. Perhaps by doing this, we could increase the productivity of below-average students' efforts.

We draw two conclusions from our study. First, it is important to disaggregate students by ability in models of student performance. The striking differences in our models of above- and below-average students show that the determinants of economics grades are quite different for the two groups. This can make an important difference in designing and implementing educational policy for the two groups.

Second, lower-ability students do not study effectively. Little research has been done to determine what study or instructional techniques are most effective for them, and the studies that have been done are now dated. Given the recent technology explosion in the field of instructional techniques, especially CAI, there is a crucial shortage of research in this area.

NOTES

1. Student attributes affect the productivity of the inputs in the production function in much the same way as technology affects a more standard production function. Therefore, variables controlling for their influence need to be included in the model.
2. Spector and Mazzeo correctly indicated that the empirical model requires a probit analysis when the variable that one is attempting to explain is not continuous. Many times, however, from a practical standpoint, an OLS model gives almost identical results. In our case, a synonymous OLS model yielded coefficient estimates that generally had the same signs but lower significance levels than the probit model estimates. For example, we would have completely missed the effect of the effort variable in all three of our models if we had estimated them with OLS because effort was insignificant in all three OLS equations (total sample, above-average sample, and below-average sample). This underscores the importance of using the theoretically correct estimation technique in empirical investigation and reinforces Spector and Mazzeo's conclusion.
3. Students were separated into the above- or below-average groups based on their scores on the ACT or SAT. We also tried separating students into above- and below-average groups based on their entering GPAs, but the two models that resulted from that division were not significantly different from one another.
4. The value of the ratio was 23.856. The chi-square test statistic with degrees of freedom equal to the number of interaction terms (7) was 20.28 at the .005 significance level.

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