Determinants of Performance in Introductory Courses In Economics and Seven Other Disciplines

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In Economics and Seven Other Disciplines

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Abstract

Using an unusually rich data set, production functions are estimated for student performance in introductory courses in Economics and seven other disciplines. Factors shown to influence success in Introductory Economics include SAT scores, student motivation, performance in high school, parent's education and the student's need for achievement. Quality of instruction also influences student performance, but student assessment of instructor quality is a poor predictor of performance. The factors most consistent in explaining performance across disciplines are SAT scores.

I. Introduction

As educators, we are interested in what influences how much our students learn. What factors, determined prior to the start of college, signal potential academic success – i.e. what should our admissions officers be looking for? What factors influencing student performance are under our control or the control of our school? In this paper we use an extremely rich data set to analyze influences on the performance of students in introductory courses in eight disciplines.

There is a substantial literature on the determinants of success in Principles of Economics courses (e.g. Becker and Salemi, 1977; Hodgin, 1984). SAT scores and student attitudes toward the course are strong predictors of performance (Rothman and Scott, 1973; Karstensson and Vedder, 1974; Siegfried and Fels, 1979; Manahan, 1983). Results are mixed regarding the independent influence of gender (Jackstadt and Grootaert, 1980; Lumsden and Scott, 1987) and of a student's intention to major in Economics (Claueretie and Johnson, 1975; Siegried and Fels, 1979). Prior training in Economics, class size, socio-economic background and a student's assessment of the quality of instruction generally do not seem to matter (Rothman and Scott, 1973; Siegfried and Fels, 1979; McConnell and Sosin, 1984).

We extend these earlier studies in two ways. First, we reduce a possibly serious missing variable bias. While most of our explanatory variables have been previously assessed in one or more studies, our extensive data set enables us for the first time to include in one production function the following comprehensive set of variables: measures of family background, high school background and performance, student attitude and aptitude, and course-specific factors. The data set also allows us to test the importance of variables, such as the student's need for achievement (defined below), not considered in any previous study.

Second, previous analyses focused exclusively on the introductory course in Economics; we extend the production function analysis to other disciplines: Art History, English, Math, Music, Philosophy, Political Science and Psychology. Are there factors important in some disciplines but not in others? Are there factors of importance in determining success in all disciplines?

We use the teacher's evaluation of the student's performance, as reflected in course grade, as the dependent variable. Scores on the TUCE (Test of Understanding of College Economics) are often used in studies of this type. Unfortunately, there are no equivalent tests for the other disciplines with which we are concerned. Use of the TUCE would, therefore, preclude meaningful comparisons. However, no significant differences emerge from a comparison of the results of parsimonious specifications of our production function with those from previous studies using the TUCE. The limitations of our dependent variable appear to be outweighed by the advantages of comparisons across disciplines.[1]

In Section II we review the theory underlying our production function analysis and describe our data. Section III presents our results for Economics. In Section IV we extend our analysis to other disciplines. The contribution of differences in grading policies across departments to the explanatory power of our model is also discussed. Section V concludes the paper.

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[1]As a further check on our dependent variable, we compared our results for Economics when course grade was the dependent variable to those when the student's score on the multiple choice portion of the final exam was the dependent variable; no differences emerge from this exercise.

II. Theory and Specification

The education production function is the analytic core of this research. In studies of the education production process this function is generally conceived to be simply a set of input-output relationships (e.g. Hanushek, 1979; Lau, 1979). Manahan (1983) applies this analytic framework to the Principles of Economics course, estimating specific forms of the following equations:

Achievement - f(ability, attitude, effort, quality of instruction)

Attitude = g(achievement, ability, effort, socioeconomic background, quality of instruction),

where achievement is a measure of learning in the course, and attitude is measure of attitude towards economics.

Among other things, Manahan tests whether these equations are truly simultaneous. He concludes that the achievement equation can be separated from the attitude equation: "The student's attitude towards economics or towards learning economics, which is established before any coursework, changes very little during an economics course" (p.16). Thus, the achievement relationship can be estimated consistently without using a simultaneous equations approach (p.14).

In our study, achievement *is* measured by the student's knowledge of the discipline at the end of the course. Ability is divided into several areas: the student's general ability, his or her prior cognitive achievement, and out of school investments in human capital. Effort is proxied by a vector of student-controlled inputs, while quality of instruction is proxied by inputs, such as the instructor, determined by the college.

To estimate this production function, we gathered proxy measures of these inputs for each of the students in our sample. Our sample consists of 394 students enrolled at Williams College, a highly selective liberal arts college, during 1985-86. Our data *come* from *student transcripts and* admissions forms, and from two surveys specially administered to students in our sample – the student course survey (for Economics students) and the Adjective Check List (Gough and Heilbrun, 1983).

Achievement is measured in two ways. First, we use the student's grade in the introductory course in the discipline as a measure of achievement. Second, for Economics only, we use the score on the common multiple choice final exam as a measure of achievement. The Economics course is a one-semester course which covers both microeconomics and macroeconomics.[2]

Following standard practice, we use the student's performance on the Math SAT as a proxy for math ability, and on the Verbal SAT as a proxy for verbal ability. Prior cognitive achievement is measured by the student's high school percentage rank. Whether the high school was a public, private or parochial school was used as a proxy for quality.[3] Ability and prior cognitive achievement variables are expected to have a positive impact on student performance.

Family background variables are included as a proxy for out of school investment in human capital. We know the highest education level attained by each parent. Our presumption is that more educated parents would transfer some of their skills and knowledge to their children. We construct from the parents' education information two variables: the highest degree received by

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2 Students in this sample took the Economics course either in the Fall of 1985 or the Spring of 1986.

3 Our prior was that private schools are higher quality than public schools; we had no prior on parochial schools.

either parent, and the difference in these degrees. This was done to avoid the collinearity resulting from use of the two parents' degrees separately. We also have a variable indicating whether the student's mother was at home or employed elsewhere during his senior year in high school, there being a presumption of stability in this relationship over time. If the mother is at home, the student is hypothesized to benefit from her greater attention and thus perform better. This is consistent with predictions of the confluence model of intelligence formation (Zajonc, 1976).

Finally, we know the student's rank in age among her siblings as well as the number of siblings the student has. In our study we expect the oldest to excel, because first born children generally are more successful and intelligent. (Zajonc (1976) summarizes some important studies in this area).[4] Also consistent with the confluence model, intellectual development generally decreases as family size increases (see Black (1989) for a summary of findings). Thus, we expect performance to decrease with number of siblings.

We have two types of proxies for current inputs: those relating to the inputs under the student's control (student time and effort) and those relating to inputs controlled by the college. For Economics only we have, from the student course survey, the student's self assessment of her motivation in the course. This should be positively related to performance. For all departments we know whether the student listed this discipline as one of two potential majors on their admissions application. Those who intend to

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[4]Consistentwith this hypothesis, the Williams population and our sample are highly selective of first born children; 56.5 percent are first born. This selectivity could, however, diminish the influence of sibling rank on academic performance once at Williams. Thus our results may underestimate the effect of sibling rank,

major in a field should, for obvious reasons, work harder and perform better than non-majors.

We also have the student's "need for achievement", an indicator developed by psychologists which is based on the student's score on the Adjective Check List (Gough and Heilbrun, 1983). Need for achievement is defined as "striving to be outstanding in pursuits of socially recognized significance." Thus

> "the high-scorer... is a hard-working, goal-directed individual, who is determined to do well and usually does...The low scorer is less effective, less venturesome, and less persistent, but at the same time an easier and more congenial companion" (p.8).

We expect a student with a higher need for achievement to work harder and thus perform better.

To measure need for achievement, students were given the Adjective Check List, a list of 300 adjectives, and asked to check those that are' self-descriptive. Thirty-eight items apply to the need for achievement scale, 25 scoring +l for each one the student checks and 13 scoring -1. Raw scores, which thus range from -13 to +25, are converted to standardized scores, which potentially range from 1 to 113 (the conversion is based on the total number of adjectives checked and the sex of the student).

Regarding inputs controlled by the college, we have, only for Economics, class size, dummy variables indicating the instructor of the section, and the student's rating of the instruction from the student course survey. We expect class size to be negatively related to performance (although the limited range of class size in our sample may not capture the effect). It is our assumption that some instructors will be better teachers than others; their students should therefore perform better. We attempt to capture difference in instructor quality in two ways: with instructor dummies, and with the student rating of the instructor.

Table 1 provides summary statistics for the variables included in the regressions. There is substantial variation in both the dependent and independent variables. Equally important, the scores on the multiple choice portion of the Economics 101 final exam – our dependent variable in two of the regressions – approximates a normal distribution, with no truncation at either end.

III. Results for Economics

Grade, our dependent variable, can only take on integer values from 0 to 12. Therefore, we used ordinal logit *to* estimate the achievement equation. Table 2 presents our regression results for Economics. The first column is a fairly standard specification.[5] The equation is significant at the 1% level. The grade predicted by our model is the same as the grade the student received in 28% of the cases. In 61% of the cases, the graded predicted by our logit model either equals the student's actual grade, or is within l/3 of a grade of the actual grade (i.e. a predicted grade of B- or B+ for a student who received a B).

As expected, and consistent with previous studies, verbal and math SAT scores positively influence performance, as does high school percentage rank and the student's self-assessment of motivation. In addition, the student's need for achievement has a strong positive influence on performance. None of

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[5] The one unusual variable, other than Need for Achievement, in this regression was "Degree of At Home Mother". This variable was zero for all mothers who worked away from home, and took the value of Mother's Degree for all mothers who were at home. We included this variable because our preliminary analysis indicated that the influence of the mother's education depended on whether she was home or not.

the family background variables, however, proved to be significant at the 5% level.

In all our regressions, the student's pre-class intention to major in Economics was insignificant. When in previous studies this variable has been significant (e.g. Claueretie and Johnson, 1975) we suspect it was due to the omission of a variable measuring student motivation. When, in our regressions, Motivation and Need for Achievement are omitted, Intended Major is generally significant.

The most notable results concern our assessment of the independent influence of the quality of instruction on student performance. To assess this, we made a number of changes in our specification and estimation procedure. The score on the common multiple choice exam is used as the dependent variable, so that instructor dummies capture difference in teaching performance and not difference in grading policies.[6] Because this dependent variable has a greater range (2-24) than student's course grade, this equation was estimated using OLS. Moreover, we adopt a more parsimonious specification, dropping from the regression variables that were insignificant in regression 1, and not significant in any of our other (unreported) regressions. Despite the fact that it was significant, we were also forced to drop Need for Achievement because of the large number of cases for which we do not have an observation.

For comparison purposes, we first ran this regression without instructor dummies (see regression 2). A comparison of regressions 1 and 2 reveals no meaningful differences. We then added instructor dummies to the regression.

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[6]Different multiple choice tests were given in the two semesters. The dummy variable for semester captures the difference in means on these two tests; it is not significant.

We used an iterative process, omitting the instructor whose students performed *"best"* relative *to their* skills, and grouping the instructor dummies that were consistently insignificant. The students of two instructors performed significantly worse and the performance of a third instructor's students just missed satisfying the criterion for statistical significance. An F-test of the null hypothesis that the addition of the instructor dummies has no impact on the predictive power of the equation was rejected at the 5% level.

This is not *a* result of selection bias. First, *most* students are randomly assigned to an instructor, and have limited opportunity to switch to a different instructor. Second, a check of the relationship between instructor dummies and variables that matter in determining student performance show no significant correlations. We conclude that the quality of teaching matters.

When we replace our instructor dummies with a variable ranking instructors according to assessments by students of the quality of instruction, this new variable is consistently insignificant. The same result is obtained when we include both instructor dummies and student assessment of the quality of instruction. These results are particularly surprising because there is a potential bias toward a positive and significant relationship between course grade and the student's assessment of the instructor's performance. Student course surveys are administered near the end of the semester. Therefore, how well students are doing in the course might be expected to influence their assessment of the quality of instruction.

It is common practice to use student course surveys to evaluate teacher performance, for example when making tenure decisions. This study demonstrates that how much a student learns is influenced by the quality of instruction, but that student evaluations of teachers are a poor guide to instructor quality. Indeed, the instructor who ranks best in the production function analysis ranks fifth (out of eight) in the student course survey ratings; i.e. the students actually learned the most from an instructor they considered to be one of the worst. If student course surveys are not measuring the effectiveness of teachers, what aspect of teacher performance do they evaluate?

IV. RESULTS FOR INTRODUCTORY COURSES IN SEVEN OTHER FIELDS

Our analysis of the determinants of performance in other disciplines was more constrained by data availability. Most notably, we lacked data on the student's motivation and on the instructor or the student's rating of the instructor. For comparative purposes, and given our findings on the sensitivity of results in Economics to missing explanatory variables, we first estimated a production function for Economics using the variables we had available for other disciplines

The results for Economics are reported in the first column of Table 3. The findings are consistent with those reported earlier: Math and Verbal SAT scores, High School Percentage Rank and Need for Achievement are all significant at the 1% or 5% level. The equation is again significant at the 1% level, and the model correctly predicts 23% of student grades, while predicting within l/3 of a grade in 58% of the cases. Thus, while we lose some explanatory power, the results of the more parsimonious specification are roughly similar to those of the richer model.

The remaining columns of Table 3 report our results on the determinants of performance in introductory courses in Art History, English, Math, Music, Philosophy, Political Science and Psychology. The results are generally consistent with our findings for Economics.

All equations are significant at either the 1% or 5% level. The model correctly predicts between 23% and 40% of student grades, while predicting between 63% and 85% of student grades within l/3 of a grade.[7] In departments such as Psychology and Economics, with grade distributions which utilize the full grade range, this is a striking result. In some of the departments, grade distributions are both high and compressed; almost all students in English, for example, receive grades close to the median. Thus our predictive success in these disciplines is less impressive. Sabot and Wakeman-Linn, (1991) provide detail on grade distributions, as well as on the relationship between mean grades and compression of grade distributions.

SAT scores – either Math or Verbal or both – are significant at the 5% level in every discipline except English. Need for Achievement is significant and of the correct sign in four of the eight regressions reported in Table 3 (Economics, English, Music and Psychology), and it is close to the 10% significance level in Political Science. High School Percent Rank, for reasons unclear to us, is insignificant in every discipline except Economics and Psychology.[S]

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7 Math is an exception to this – for reasons unclear to us, the model predicts only 41% of Math grades within l/3.

8We considered and rejected several possible explanations of this result. First, this result is not being driven by larger sample size; random reductions in sample size for Economics does not eliminate the significance of high school percent rank. Second, it is not the result of collinearity between SAT scores and high school percent rank. The correlation among these variables is lower in many of the other disciplines than in Economics. Further, high school percent rank is not significant in these disciplines even when SAT scores are excluded from the regression. Finally, the significance of high school percent rank in Economics is not being driven by a few outliers; when all outliers are deleted from the sample, high school percent rank is still significant in Economics.

Parents' education does not matter in these regressions. In unreported regressions which entered Mother's Degree and Father's Degree separately, rather that the Maximum Degree and Difference in Degrees, one or the other Degree variable was occasionally significant.

In Art History, English and Math women performed significantly better than men with similar characteristics. Intended Major was consistently insignificant at the 5% level in all disciplines, except Political Science.

V. Conclusion

Our aims have been to analyze the determinants of student performance in introductory Economics, and to draw comparisons with the determinants in other disciplines. Our rich data have enabled us to estimate more comprehensive production functions and to explain some previously conflicting findings by missing variable bias. Family background variables, such as parent's education and number of siblings, matter only occasionally, while intended major, and perhaps gender, appear to merely proxy for other variables. Differences among instructors in teaching ability influence student performance, but the ranking by students of their teachers does not accord with teacher effectiveness. Our findings cast doubt on student course surveys as devices to measure teacher effectiveness.

Our production function analyses of other departments is novel. The most striking feature to emerge from this analysis pertains to SAT scores. The SAT consistently predicts performance in seven of the eight disciplines. Math and Verbal SAT scores are strong predictors even in disciplines, such as Music, where one might not expect them to matter. The predictive power of SAT scores is as strong in disciplines, such as Philosophy, that rely on papers to assess students, as in disciplines, such as Economics and Math, that rely more on tests. This result provides support for the emphasis placed on SAT scores by offices of admission. Finally, the student's need for achievement, a variable unique to this study, has a strong influence on student performance in many disciplines.

An attractive feature of this study is its replicability. Our data, while extremely rich, are hardly unique. Equally rich veins of data are to be found in the Registrar's office of all colleges and universities and, institutional rules permitting, are available for mining by their faculty.

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Table 1

	Mean	Std. Dev.	Minimum	Maximum
Math SAT's	670.3	70.93	370	800
Verbal SAT's	634.6	79.75	300	800
Sex (l=female)	.383	.487	0	1
Intended Major (Econ) (l-intended major)	.150	.357	0	1
High School % Rank[1]	13.62	9.04	0	90
Motivation (4=low, l-high)	2.456	.610	1	4
Sibling Rank (l=oldest)	1.877	1.217	1	7
Number of Siblings	1.159	1.331	0	11
Mother at Home (l=home)	.344	.476	0	1
Mother's Degree[2]	3.213	1.536	0	5
Father's Degree[2]	4.247	1.931	0	5
Highest Degree of parents	4.35	1.89	0	5
Difference in Degrees	1.39	1.56	0	5
Degree of at Home Mom[3]	.938	1.494	0	5
Need for Achievement	47.79	9.585	20	72
Size of 101 section	30.82	4.27	23	39
Private High School (l=private)	.387	.652	0	1
Parochial High School (l-parochial)	.068	.501	0	1
Economics Grade[4]	7.014	2.2	0	11
Art History Grade[4]	7.987	1.747	1	11
English Grade[4]	8.093	1.599	0	11
Math Grade[4]	6.070	3.419	0	12
Music Grade[4]	8.000	1.599	4	11
Philosophy Grade[4]	7.738	1.668	2	11
Political Science Grade[4]	8.344	1.492	4	11
Psychology Grade[4]	7.064	2.422	1	12
Multiple Choice Score	13.76	3.672	2	24

<u>Table Notes</u>

1. To the nearest 10%; lO=top 10% 0 = top student in class.
2. l=high school, 2=attended college, 3=Bachelors, 4=masters, 5=terminal degree
3. 0 if mother worked outside the home, mother's degree otherwise
4. 12=A+, ll=A, 10=A- 9=B+, 8=B, 7=B-, 6=C+, 5=C, 4=C-, 3=D+, 2=D, l=D-, O=F

Table 2: Economics[1]

	Regression 1	Regression 2	Regression 3
Math SAT's	.0127 (5.65)	.0096 (3.14)	.0095 (3.12)
Verbal SAT's	.0052 (2.27)	.0090 (3.34)	.0088 (3.26)
Sex	-.4264 (1.52)	-.5499 (1.34)	-.5533 (1.36)
Intended Major	-.1497 (0.34)	.8808 (1.55)	.8113 (1.42)
High School % Rank	-.0252 (2.20)	-.0230 (1.35)	-.0306 (1.38)
Semester	-.0932 (0.25)	-.3765 (0.90)	.2624 (0.46)
Motivation	-.8472 (3.31)	-1.112 (3.49)	-1.083 (3.39)
Sibling Rank	-.2476 (0.81)	-.3049 (1.55)	-.3136 (1.58)
Number of Siblings	-.0282 (0.24)	.3112 (1.74)	.2828 (1.57)
Mother at Home	.2791 (0.30)	-.2626 (0.62)	-.9927 (0.93)
Highest Degree of Parents	.1910 (1.59)	.1487 (1.02)	.1271 (0.76)
Difference in Degrees	-.0518 (0.37)		
Degree of at Home Mom	.1669 (0.51)		
Need for Achievement	.0253 (1.80)		
Size of 101 section	.0204 (0.44)		
Public High School	-.1830 (0.57)		
Parochial High School	-.6459 (0.51)		
Instructors 1,5,7,8			-.4035 (0.66)
Instructor 2			-1.227 (1.75)
Instructor 3			-1.833 (2.07)
Instructor 6			-1.254 (1.39)
Number of students	210	305	305
Likelihood Ratio Chi Square	127.09		
(probability)	(.9993)		
F-Statistic		5.82	4.68
(significance)		(0.00)	(0.00)
Percent Correctly Predicted	28.1		
Percent% Predicted Within l/3 of a Grade	61.0		

Table Notes

1. Numbers are logit coefficient estimates for regressions 1 and 3, OLS coefficient estimates for regression 2. Numbers in parentheses are T-statistics. Dependent variable is grade in Economics 101 for regression 1, score on the multiple choice portion of the final exam for equations 2 and 3.

Table 3[1]

	Economics		Art History		English		Math	
Math SAT	.0105	(5.92)	.003	(0.85)	.001	(0.48)	.0226	(3.46)
Verbal SAT	.0029	(1.88)	.0117	(3.36)	.003	(1.32)	-.0032	(0.09)
Number of Sibs	-.0029	(0.03)	-.1139	(0.67)	-.2274	(1.28)	-.1358	(0.63)
Sex	-.2124	(0.95)	1.070	(2.15)	.6779	(2.14)	.6004	(1.10)
Maximum Degree	.0867	(1.01)	-.1392	(0.56)	-.0971	(0.69)	-.1249	(0.53)
Degree Diff.	.0856	(1.27)	.1208	(0.44)	.0794	(0.47)	.0657	(0.21)
Intended Major[2]	.3603	(0.99)			.4283	(1.02)	.4753	(0.84)
Sibling Rank	.1746	(0.74)	-.5347	(0.11)	-.5666	(1.58)	-.1655	(0.32)
HS % Rank	-.0346	(3.27)	-.0011	(0.03)	-.0143	(.98)	-.0265	(0.74)
Need for Ach.	.0077	(1.70)	.0287	(1.21)	.0266	(1.64)	-.0351	(1.41)
Number of Students	303		81		166		84	
Likelihood Ratio								
Chi Square	92.32		35.32		21.15		28.74	
(probability)	(1.00)		(.9986)		(1.00)		(.9999)	
Percent Correctly Predicted	23.43		39.51		32.53		25.00	
% Predicted Within 1/3 of a Grade	58.1		85.2		69.4		40.9	

	Music		Philosophy		Pol. Science		Psychology	
Math SAT	.0091	(2.45)	.0118	(1.99)	.0048	(1.33)	.0066	(2.31)
Verbal SAT	.0086	(2.30)	.0132	(2.08)	.0102	(3.24)	.0131	(4.17)
Number of Sibs	-.3683	(1.15)	-.0852	(0.20)	.2013	(1.83)	-.0476	(0.32)
Sex	.5105	(0.92)	1.090	(1.33)	-.3256	(0.77)	.4403	(1.06)
Maximum Degree	-.1047	(0.34)	.0999	(0.32)	.0061	(0.03)	.1250	(0.79)
Degree Diff	.1334	(0.36)	.1514	(0.52)	.1160	(0.54)	.1588	(0.76)
Intended Major[2]	3.646	(0.08)			.6871	(1.70)	1.157	(1.26)
Sibling Rank	-1.372	(2.09)	-.1630	(.18)	.7173	(1.51)	-.6116	(1.20)
HS % Rank	-.0028	(0.14)	.0326	(1.41)	-.0036	(0.26)	-.0497	(1.64)
Need for Ach.	.0451	(1.67)	.0384	(0.98)	.0336	(1.40)	.0411	(1.81)
Number of Students	70		53		109		113	
Likelihood Ratio								
Chi Square	32.38		19.80		29.33		48.24	
(probability)	(.9886)		(.9907)		(1.00)		(1.00)	
Percent Correctly Predicted	24.29		37.74		36.70		23.01	
% Predicted Within 1/3 of a Grade	72.9		77.3		78.8		62.9	

Table Notes

1. Numbers are logit coefficient estimates. Numbers in parentheses are T-statistics.
2. There were no students who intended to major in Art History or Philosophy in our sample.