Not yet for quotation. Comments welcome.

35,000 Principles Students: Some Lessons Learned

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I. Introduction

One of the most dismal assertions ever made about teaching the "dismal science" was tendered by George J. Stigler in his American Economic Association presidential address. Stigler suggested that after five years, students would retain little or nothing of what they learned in a principles of economics course (1963, p. 657). If Stigler is correct, this may explain why so many economists can restrain their enthusiasm for teaching introductory courses: a nagging concern that nothing of lasting value results from their labor.

Nonetheless, in U.S. colleges and universities, the principles of economics course remains the most common entry point for economic education, and the number of students majoring in economics has risen in recent years (Siegfried, 2006).[2] No single

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[2] Newsweek has reported that economics currently is the "sexiest" field of study. (12/26/2005, p. 21) See also "Economics: The sexy social science?" by John Hamilton, Gail M. Hoyt, W.D. McMillin, John J. Siegfried, A.R. Sanderson, and Michael Watts (2003).

course within the economics major approaches in size the number of students who enroll in the traditional two-semester course in micro and macro principles or the one-semester micro-macro blend, taught at virtually all colleges and universities. Given such enormous enrollment in principles of economics, it is not surprising that economists have been interested in evaluating this class more than any other in the economics curriculum.

A thirty-two year review of the *Journal of Economic Education* (1975-2006) produced 70 articles on the principles course, far more than on any other single course.[3] Economists who have placed the principles course under their lens in the past five years include: Krueger (2001); Cohn, Cohn, Balch, and Bradley (2001); Grimes (2002); Kaufman and Kaufman (2002); Colander (2003); Jensen and Owen (2003); Bosshardt (2004); Ballard and Johnson (2004); Colander (2004); Wang and Yang (2004); Eckenrod and Holahan (2004); Stance (2006); and Dickie (2006).

Presumably, economists believe that learning the elements of economic analysis can be one way for students to invest in human capital during their years of college and university education.[4] Indeed, ever since Becker's seminal work (1964), teachers of economic principles have emphasized to their students that by studying economics, they are making an investment in their own human capital.[5] Because economic education is a form of capital investment, and because so many students first encounter economics in a principles course, it would be fruitful if economists understood how the principles course

[3] The same review uncovered 12 articles on intermediate macroeconomics, 7 on intermediate microeconomics, 8 on international trade, 6 on econometrics, 7 on experimental economics, and 7 on graduate courses regardless of field

[4] We note that economics increasingly is being taught at the high school level. The number of students taking either AP Micro or Macroeconomics has risen rapidly since the inception of the tests in the late-1980's. For example, 97,499 high school students took an AP economics exam in 2007, while only 26,770 students took one of the two exams in 1997. As part of this study we evaluate the role of AP credit on student performance in college-level economics courses.

[5] For example, in Michael Parkin's textbook students are told, "You are building human capital right now as you work on your economics course . . . ." (2000, p. 36)

generated capital, what this stock of human capital looks like, and what accounts for different rates of capital accumulation among students taking courses in principles of economics.

Research on the principles course typically responds to questions such as:

1. What difference in the educational output of the principles course is associated with exogenous variables such as gender or students' prior exposure to high school courses in the principles of economics? Over forty years ago, George L. Bach and Phillip Saunders concluded that men do better (in terms of grades) in economics courses than women (1965). Several subsequent studies have reported results consistent with the Bach-Saunders data.[6]
2. What difference in output is associated with endogenous variables such as the use of educational technology or variations in class size? For example, Sosin, Blecha, Agarwal, Bartlett and Daniel (2004, p. 257) report results suggesting that extensive use of technology in the principles course has a "small but positive impact on student performance." [7] James Arias and Douglas M. Walker (2004, p. 311) recently concluded that class size makes little difference in student learning.[8]
3. How can the classroom content in economic principles be communicated to teach principles of economics more effectively?[9] Most economics is taught by the

[6] Some of this literature is discussed later in this paper. Teaching economics in high school seems to fall within the Stigler prediction: the incremental effect of prior instruction in economics upon college level performance is, at best, mixed (Fels and Siegfried, 1979).

[7] For a more positive assessment of the impact of technology, see Ball, Eckel, and Rojas (2006) on the use of Wireless Interactive Teaching Systems.

[8] This line of research has long been heartening to those who teach "large" introductory courses. The result has stood the test of time. For earlier studies that also found that class size did not influence test scores, see Levin (1967), Dahl and Lewis (1972) and Mirus (1973).

[9] Notwithstanding the increasing use of educational technology and game theory in the principles course, the introductory course conventionally is taught using comprehensive textbooks. For an analysis of the first blockbuster textbook in economics, see Elzinga (1992) and Mark Skousen (1997).

"chalk and talk" method (Becker and Watts, 2001). Very little is written that pertains to lecturing on the subject of economics in the classroom. [10]

4. How can classroom experiments be used to increase learning in the principles of economics course? Mark Dickie (2006) argues that using experiments enhances performance more than grade incentives. Classroom experiments are hot, and there is an extensive literature on their use.[11]
5. Does classroom seating location or classroom attendance affect student performance in the principles of economics course? Benedict and Hoag (2004) conclude that sitting at or near the front of the class is associated with better grades.[12]
6. What effect does learning the principles of economics have on a student's political perspective? Jackstadt, Brennan, and Thompson (1985) investigated Stigler's hypothesis that the study of economics makes one more politically conservative and concluded with mixed results that the principles course has this consequence.
7. How can the textbook in economic principles be used or written to teach principles of economics more effectively? Karns, Burton, and Martin (1983, p. 16) examined six different principles textbooks to ascertain which "provided [the] resources needed by the students to meet the learning objectives set for the course."

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[10] For recent exceptions, see Elzinga (2001), Frank (2002), and Hamermesh (2002). See also Byrns and Stone (1984) and Hallagan and Donnelly (1985).
[11] For a more general assessment of the use of experiments in teaching economics, see Holt (1999).
[12] The nexus between seating and class performance is sobering for teachers who diligently work to prepare lectures. Forcing students somehow to the front of the room may be worth hours of preparation time!

Two important books that incorporate many of these findings and offer additional content on the introductory economics course are *Teaching Undergraduate Economics*, edited by Walstad and Saunders (1998), and *Teaching Economics to Undergraduates: Alternatives to Chalk and Talk*, edited by Becker and Watts (1998).[13]

II. Education and Human Capital

Most of the research on the principles course in particular (and economic education generally) is based on cross-section data and a fairly small number of observations. Typically, analysts (usually professors of economics) select two sets of similar students; one group is exposed to a set of educational inputs different from that of the control group. Analysts test for variations in student performance attributable to the difference in teaching practices or course content. Or, as an alternative, two sets of students who have different initial endowments are taught principles in the same way in order to test for endowment-specific effects on student performance in an introductory course. Many scholars who study the principles course do so in part to make the courses more valuable to student-consumers. Our study is in this grain.

Through our connection with the University of Virginia (UVA), we have developed an unusually rich database of students who took principles of microeconomics (Econ 201) over a period of almost twenty years from Kenneth G. Elzinga, the senior author of this paper. Elzinga joined the UVA faculty in the fall of 1967. Every year since, with an exception for government service, he has taught a large class of micro principles at UVA (teaching over 35,000 students during this time span). The junior

[13] Another important source, is Becker (1997). See also, Becker (2000).

author of this paper, Daniel Melaugh, enrolled at UVA in the fall of 2003 and majored in economics.[14]

III. Questions Explored

Topics we explore through an analysis of this database are conventional ones such as male-female and racial differences in class performance; first-year versus upper-class differences in achievement; and high school SAT scores, high school GPA, and AP credit as predictors of success in the college-level introductory course. In addition, because of the nature of our database, we can explore relatively unexamined terrain such as in-state, out-of-state, and legacy student differences in class performance, as well as differences in performance between students in the College of Arts & Sciences and those enrolled in the School of Engineering and Applied Sciences and the School of Architecture at UVA. In addition, we examine performance differentials between athletes and transfer students from the general student population. After assessing what factors affect a student's performance in Econ 201, we endeavor to ascertain how success in an introductory microeconomics course predicts performance in more advanced college courses.

IV. Econ 201: Ceteris Paribus Conditions Met and Unmet

In order to test variables that interest us (and might be of interest to other scholars of economic education), we assume that certain variables remain the same during the time of analysis (or that any changes are of no consequence). These are the factors that have remained unchanged over the decades in Elzinga's Econ 201 class.

[14] Melaugh was never a student in Econ 201 at UVA (having earned AP credit for the course in high school). His objectivity offsets internal blinders Elzinga brings to this study from having been the course's instructor for many years.

1. The class format has not changed in 40 years: the course always meets during the fall semester of a traditional two semester academic calendar.
2. The assigned textbook always has been the "micro-half" of a comprehensive textbook (a split has never been assigned).
3. The course has been offered on the same days of the week (Tuesday and Thursday) in the same time slots (back-to-back lectures at 11:00 and 12:30) and in the same 500-seat auditorium.[15]
4. Educational technology has remained unchanged (microphone and overhead projector[16]).
5. The test format has been constant.[17]
6. The number of credit hours has remained constant at three.
7. Like many large introductory courses in economics (as well as other disciplines), students meet with Teaching Assistants in small discussion sections for one contact hour per week. The Teaching Assistants always have been graduate students in economics (not undergraduates).
8. The class consistently has been offered in the College of Arts and Sciences at UVA, not in the undergraduate school of business, and always has been taught in the liberal arts grain (not as a course in business administration). The course is required for admission to UVA's McIntire School of Commerce (a two year undergraduate program in business).
9. Enrollment in Econ 201 always has been large (in the hundreds). Early on, the course could enroll all students who sought entrance; for most of our analysis, the course has been oversubscribed and enrollment is constrained by the size of the auditorium to slightly more than 1000 students.[18]

We are unaware of any other principles of economics course with this degree of continuity and large student population.

Some elements of the educational mix have changed over the years. First, while the textbook always has been a comprehensive one, the assigned textbook has not always been by the same authors. The course first used a textbook by Lipsey & Steiner, then

[15] In his first three years at UVA, Elzinga's class met in a performing arts auditorium. This auditorium was larger and enrollment was then smaller, so there were no back-to-back lectures at that time.

[16] For pedagogical reasons, Elzinga has not adopted Powerpoint presentations. However PowerPoint software is now used to prepare many of the transparencies for the overhead projector.

[17] Two mid-semester exams are given and one final examination. The cumulative final letter grade is based on these scores combined with a performance metric from a discussion section. Students also can receive a final letter grade based on the final examination alone if that grade is higher than their cumulative grade. Thus, it is possible to do poorly on the first two tests and still receive a high grade if a high grade on the final is earned.

[18] This Econ 201 class is not the only micro principles class offered at UVA, but it is the only principles course taught in a large -lecture format. During both the fall and spring semester, there are smaller sections of Econ 201 offered at UVA, typically (but not always) taught by graduate students who have been teaching assistants in the large-lecture class.

Stiglitz, then McEachern, and currently requires Gwartney, Stroup, Sobel and MacPherson.[19] Second, Econ 201 at UVA originally was "hyphenated" with Econ 202 (principles of macroeconomics). Hyphenated courses meant credit in one course would not be counted by the registrar unless the other course was successfully completed.[20] However, the hyphenated nature of the course was terminated prior to the database used in our regression analysis. Third, the quality of classroom teaching may have changed over time. While Elzinga has been the course's instructor for almost 40 years, he likes to believe that he is a better teacher today than at the start of his career.[21] Fourth, the quality of students may have changed over time. UVA contends it is a higher caliber institution than it was forty years ago and one that attracts better students. Fifth, the deadline for students to drop a course was changed during this time period. Prior to 1996, the undergraduate course drop date occurred six weeks after the first day of class, but beginning in the fall of 1996, the deadline to drop a course was pushed up to two weeks after the first day of class. Students now presumably have less information to predict whether they are in danger of failing the course and should withdraw before receiving a low grade. Finally, while Econ 201 at UVA continues to use the large-lecture, discussion section format, the Department of Economics no longer requires Teaching Assistants in Econ 201 to have completed one year of graduate studies. As a consequence, most Teaching Assistants in the course are first year graduate students.[22]

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[19] For the student population evaluated here. The Samuelson text also was assigned to a prior group of students.

[20] Some students at UVA disliked the hyphenated character of the course, especially those who barely passed Econ 201.

[21] Elzinga has been awarded several teaching commendations. The award given by the Southern Economic Association to honor teaching is named after him.

[22] While we do not have data on this, more Teaching Assistants today would be international students (for whom English is a second language) than would have been the case at UVA twenty years ago.

In order to control for some of these changes, we have introduced several control variables into our regression model that we will outline in a following section. For instance, a year variable is used to control for changes in both the quality of Elzinga's teaching and any grade inflation. Furthermore, a dummy variable was introduced to control for the change in the drop deadline policy.

V. The Database

Elzinga's teaching career predates computerized retention of certain bits of data. Consequently, while we can draw from a "database" of over 35,000 students for some information, our analysis is largely based on data gathered from administrative records pertaining to the 15,616 students who have taken Econ 201 from Elzinga since 1989. This smaller but still substantial database has complete and comparable records for each student that contain demographic characteristics, pre-college achievement measures, and grades attained while attending UVA. (See Table 1 for descriptive statistics.)

The available demographic characteristics include a student's gender, race, year of study (i.e., freshmen, sophomore, junior, senior), school (College of Arts and Science, School of Engineering and Applied Sciences, School of Architecture), transfer student status, athlete status, in-state status, and legacy status. The athlete distinction divides Econ 201 students into one of the following three categories: high profile athletes (defined as students who compete on either the men's football or basketball teams), all other athletes, and non-athletes. Transfer students are sub-divided based on whether they transferred to UVA from a four-year college or a two-year community college.

Pre-college achievement measures include a student's SAT math score, SAT verbal score, amount of advanced placement credits, and high school GPA. The College Board introduced a re-centered SAT scoring scale in 1995, so we adjusted any scores obtained from 1989-1994 accordingly to fit this scale. The high school GPA measure is only available for students who took Econ 201 after 1996 and only 70% of those students had a high school grade point average record. All GPA records in our database are based on a 4-point scale, and the missing records might simply be students who were graded on a different scale in high school, e.g., a 100-point scale. After testing to compare the students with high school grade records against those who do not, we are confident that the selection is unbiased.

UVA grade measures include the final grade each student obtained in Elzinga's Econ 201 course. In addition, if a student elected to pursue additional economics coursework, we have the grades these students received in introductory macroeconomics (Econ 202), intermediate microeconomics (Econ 301), and intermediate macroeconomics (Econ 302). Our database also includes a student's cumulative GPA upon graduation in all courses, economics courses, and courses taken in UVA's McIntire School, a top ranked undergraduate business school for which Econ 201 is a pre-requisite for admittance.

Table 1. Sample Means and Standard Deviations

Variable	Mean	Standard Deviation	Minimun	Maximum	N
Demographic Characteristics					
First Year	0.188	0.390	0	1	15616
Second Year	0.500	0.500	0	1	15616
Third Year	0.233	0.423	0	1	15616
Fourth Year	0.079	0.270	0	1	15616
Male	0.512	0.500	0	1	15616
Female	0.488	0.500	0	1	15616
Caucasian	0.785	0.411	0	1	15616
African American	0.060	0.237	0	1	15616
Asian American	0.098	0.298	0	1	15616
Native American	0.002	0.045	0	1	15616
Hispanic American	0.025	0.157	0	1	15616
Non-Resident	0.029	0.168	0	1	15616
College of Arts & Sciences	0.873	0.332	0	1	15616
School of Engineering	0.110	0.313	0	1	15616
School of Architecture	0.016	0.127	0	1	15616
In-State	0.649	0.477	0	1	15616
Out-of-State	0.351	0.477	0	1	15616
Legacy	0.142	0.349	0	1	15616
Non-Legacy	0.858	0.349	0	1	15616
High Profile Athlete	0.005	0.068	0	1	15616
Other Athlete	0.037	0.188	0	1	15616
Non-Athlete	0.959	0.199	0	1	15616
Community College Transfer	0.004	0.063	0	1	15616
Four Year College Transfer	0.028	0.165	0	1	15616
Non-Transfer	0.967	0.179	0	1	15616
Prior Performance Measures					
SAT Verbal	673.184	75.833	280	800	15616
SAT Verbal 700-800	0.399	0.490	0	1	15616
SAT Verbal 600-690	0.460	0.498	0	1	15616
SAT Verbal 500-590	0.125	0.331	0	1	15616
SAT Verbal < 500	0.016	0.125	0	1	15616
SAT Math	670.901	69.086	380	800	15616
SAT Math 700-800	0.361	0.480	0	1	15616
SAT Math 600-690	0.509	0.500	0	1	15616
SAT Math 500-590	0.123	0.329	0	1	15616
SAT Math < 500	0.007	0.083	0	1	15616
High School GPA	3.992	0.362	1.02	5	6744
Advanced Standing Hours	9.622	10.516	0	66	15616
UVA Grade Measures					
Econ201 Grade	2.74	0.93	0	4	15772
Econ202 Grade	2.87	0.81	0	4	9576
Econ301 Grade	3.02	0.77	0	4	3835
Econ302 Grade	3.04	0.78	0	4	2918
Cummulative GPA	3.22	0.44	0	4	15772
Economics GPA	2.72	0.86	0	4	15731
Commerce GPA	3.16	0.68	0	4	8420

VI. Predicting Econ 201 Grades: The Model

Due to the non-linear, discrete nature of the dependent variable in this study (a student's grade in Econ 201 that is based on a 4 point plus/minus scale), we utilized an ordered probit regression model. Our model is similar to Yang and Raehsler's (2005), which was used to predict what factors contribute to a student's performance in an intermediate microeconomics course at Clarion University. Since grade values are inherently ordinal in nature, with letter grades F, D-, D, D+, C-, C, C+, B-, B, B+, A-, and A/A+ corresponding to 0.0, 0.7, 1.0, 1.3, 1.7, 2.0, 2.3, 2.7, 3.0, 3.3, 3.7, and 4.0 respectively, they readily lend themselves to this type of analysis.

An ordered probit model uses observed points in a dataset to predict values of an unobserved (latent) variable, y*, such that:

$$y^* = x\beta + \varepsilon \quad (1)$$

where x are explanatory variable matrices, β are parameter matrices, and ε are independent, identically distributed error terms. The observed values of y are based on y* and can take on 12 values:

$$y = 0.0 \text{ (grade of F) if } y^* \leq \mu_1 \quad (2)$$
$$y = 0.7 \text{ (grade of D-) if } \mu_1 < y^* \leq \mu_2 \quad (3)$$
$$y = 1.0 \text{ (grade of D) if } \mu_2 < y^* \leq \mu_3 \quad (4)$$
$$y = 1.3 \text{ (grade of D+) if } \mu_3 < y^* \leq \mu_4 \quad (5)$$
$$y = 1.7 \text{ (grade of C-) if } \mu_4 < y^* \leq \mu_5 \quad (6)$$
$$y = 2.0 \text{ (grade of C) if } \mu_5 < y^* \leq \mu_6 \quad (7)$$
$$y = 2.3 \text{ (grade of C+) if } \mu_6 < y^* \leq \mu_7 \quad (8)$$
$$y = 2.7 \text{ (grade of B-) if } \mu_7 < y^* \leq \mu_8 \quad (9)$$
$$y = 3.0 \text{ (grade of B) if } \mu_8 < y^* \leq \mu_9 \quad (10)$$
$$y = 3.3 \text{ (grade of B+) if } \mu_9 < y^* \leq \mu_{10} \quad (11)$$
$$y = 3.7 \text{ (grade of A-) if } \mu_{10} < y^* \leq \mu_{11} \quad (12)$$
$$y = 4.0 \text{ (grade of A or A+) if } \mu_{11} \leq y^* \quad (13)$$

where the μ_i (for i = 1, 2, …, 11) are threshold variables in the model that are determined in the maximum likelihood estimation of the ordered probit.

Our most general regression uses all demographic characteristics and pre-college achievement measures (except high school GPA) as explanatory variables and is defined:

$$y_i = \beta_1 \text{ FIRST YEAR}_i + \beta_2 \text{ SECOND YEAR}_i + \beta_3 \text{ THIRD YEAR}_i + \beta_4 \text{ MALE}_i + \beta_5 \text{ BLACK}_i + \beta_6 \text{ ASIAN}_i + \beta_7 \text{ NATIVE AMERICAN}_i + \beta_8 \text{ HISPANIC}_i + \beta_9 \text{ INTERNATIONAL}_i + \beta_{10} \text{ ENGINEERING}_i + \beta_{11} \text{ ARCHITECTURE}_i + \beta_{12} \text{ IN-STATE}_i + \beta_{13} \text{ LEGACY}_i + \beta_{14} \text{ HIGH PROFILE ATHLETE}_i + \beta_{15} \text{ ATHLETE}_i + \beta_{16} \text{ CC TRANSFER}_i + \beta_{17} \text{ TRANSFER}_i + \beta_{18} \text{ SAT VERBAL}_i + \beta_{19} \text{ SAT MATH}_i + \beta_{20} \text{ AP CREDITS}_i + \varepsilon_i \quad (14)$$

As outlined by Greene (1991), the probability of a student, y_i, achieving one of the twelve possible letter grades in Econ 201 [given values of their explanatory variables $(x_i \beta_i)$] is defined by the following system of equations:

$$P(y = 0.0) = \Phi(\mu_1 - x\beta) \quad (15)$$
$$P(y = 0.7) = \Phi(\mu_2 - x\beta) - \Phi(\mu_1 - x\beta) \quad (16)$$
$$P(y = 1.0) = \Phi(\mu_3 - x\beta) - \Phi(\mu_2 - x\beta) \quad (17)$$
$$P(y = 1.3) = \Phi(\mu_4 - x\beta) - \Phi(\mu_3 - x\beta) \quad (18)$$
$$P(y = 1.7) = \Phi(\mu_5 - x\beta) - \Phi(\mu_4 - x\beta) \quad (19)$$
$$P(y = 2.0) = \Phi(\mu_6 - x\beta) - \Phi(\mu_5 - x\beta) \quad (20)$$
$$P(y = 2.3) = \Phi(\mu_7 - x\beta) - \Phi(\mu_6 - x\beta) \quad (21)$$
$$P(y = 2.7) = \Phi(\mu_8 - x\beta) - \Phi(\mu_7 - x\beta) \quad (22)$$
$$P(y = 3.0) = \Phi(\mu_9 - x\beta) - \Phi(\mu_8 - x\beta) \quad (23)$$
$$P(y = 3.3) = \Phi(\mu_{10} - x\beta) - \Phi(\mu_9 - x\beta) \quad (24)$$
$$P(y = 3.7) = \Phi(\mu_{11} - x\beta) - \Phi(\mu_{10} - x\beta) \quad (25)$$
$$P(y = 4.0) = 1 - \Phi(\mu_{11} - x\beta) \quad (26)$$

where $\Phi(.)$ denotes the normal cumulative distribution function.

VII. Predicting Econ 201 Grades: General Comments on Results

Our most general ordered probit regression uses all demographic characteristics and pre-college achievement measures to predict a student's grade in Econ 201 as defined by equation (14) above. For full results, see Table 2. Almost all variables are statistically significant at the 99% level of confidence, the exceptions being Native American students, Engineering students, and both two-year and four-year college transfer students. Both control variables are significant: the year variable indicates that student performance is inversely related to time (perhaps an indication of grade

deflation), and the dummy variable controlling for the drop deadline being pushed earlier in the semester indicates that the change positively affected student performance. As this finding is rather counterintuitive, we believe that some of the significance of this result can be attributed to the effect of the year variable.

Table 2. Predicting Econ 201 Grade - Ordered Probit Results (n=15616)

	Coefficients	Standard Error	P-Value
Control Variables			
Year	-0.023	0.0030	0.000
Pre-Drop Deadline Change	-0.512	0.0322	0.000
Demographic Characteristics			
First Year	-0.276	0.0370	0.000
Second Year	-0.167	0.0320	0.000
Third Year	-0.122	0.0340	0.000
Male	0.109	0.0173	0.000
African American	-0.359	0.0376	0.000
Asian American	-0.173	0.0285	0.000
Native American	-0.256	0.1816	0.158
Hispanic American	-0.214	0.0524	0.000
Non-Resident	0.306	0.0529	0.000
School of Engineering	0.030	0.0282	0.290
School of Architecture	-0.480	0.0644	0.000
In-State	-0.057	0.0185	0.002
Legacy	-0.134	0.0241	0.000
High Profile Athlete	-0.423	0.1229	0.001
Other Athlete	-0.141	0.0447	0.002
Community College Transfer	-0.002	0.1299	0.986
Four Year College Transfer	-0.008	0.0501	0.872
Prior Performance Measures			
SAT Verbal	0.003	0.0001	0.000
SAT Math	0.005	0.0002	0.000
Advanced Standing Hours	0.019	0.0010	0.000
Threshold Values			
μ_1	-43.67		
μ_2	-43.32		
μ_3	-43.10		
μ_4	-42.86		
μ_5	-42.35		
μ_6	-41.95		
μ_7	-41.57		
μ_8	-41.21		
μ_9	-40.75		
μ_{10}	-40.35		
μ_{11}	-39.64		
Scaled R^2	0.09		

Using the system of equations defined by (15) through (26), we calculated the probability of an average student (defined by the means of each of the independent variables as found in Table 1) receiving one of the twelve possible letter grades. As conventional logic would suggest, a statistically average student is more likely to achieve an average grade ranging from a C to a B+ than the true grade distribution of the sample would suggest (See Table 3 below).

Table 3. Expected Probability of Obtaining a Certain Letter Grade

	Grade Distribution	E[P-Value] at Mean
F	2.171%	0.627%
D-	1.998%	0.978%
D	1.831%	1.110%
D+	2.677%	1.917%
C-	8.344%	7.432%
C	9.375%	9.964%
C+	11.085%	12.983%
B-	11.353%	13.806%
B	14.677%	17.818%
B+	11.488%	13.205%
A-	14.517%	13.965%
A/A+	10.483%	6.189%

Using the threshold values, μ_i, calculated by the ordered probit model, the marginal effects of the independent variables also were calculated at their mean values. A marginal effect demonstrates how a small change in an explanatory variable affects the dependent variable, in this case a student's final grade in Econ 201. The marginal effect calculation is defined for continuous variables as the partial derivative of the probability of achieving any one grade, with respect to the explanatory variable. For dummy explanatory variables, the calculation is more nuanced since small changes in their value cannot be observed (as they only take the value of zero or one). Full results of our

marginal effects calculation can be found in Table 4 in the appendix. We now turn to interpreting both the ordered probit regression and the marginal effects estimation for both demographic characteristics and pre-college achievement measures.

VIII. Predicting Econ 201 Grades: Demographic Characteristic Results

The ordered probit regression indicates that less experienced students perform poorly relative to more experienced students in their fourth year of study. As the regression coefficients suggest, this finding is consistent across all ages with students in their first year of study doing the worst, followed by students in their second and third years respectively. The marginal effects estimation implies that a statistically average first year student is roughly half a percent more likely to get an F and three percent less likely to get an A or A+ than a fourth year student. This finding agrees with similar studies. For example, Anderson, Benjamin, and A. Fuss (1994) also found a maturity premium exists among students in introductory economics courses.

One intriguing result that we will examine in more detail below is the existence of a male grade premium. Over the eighteen year period, men outperformed females by roughly two-tenths of a grade point in absolute terms with the average male grade being 2.84 and the average female grade being 2.66. Similar results have been documented in other studies that examine the relationship between gender and performance in economics courses [such as Siegfried and Strand, (1977); Lumsden and Scott, (1987); Heath, (1989); Anderson, Benjamin, and Fuss, (1994)].

A dummy variable to indicate a student's race also was included in the regression model, and all minority classifications were regressed against Caucasians. It was found

that non-U.S. resident, international students performed significantly better than Caucasians, while Native American students performed relatively the same. African American, Asian American, and Hispanic American students all performed worse than their Caucasian classmates, ceteris paribus. The average African American student is 5.31% less likely to obtain an A- in Econ 201 than the average Caucasian student, while Hispanic and Asian students are 3.27% and 2.68% less likely respectively.

Another significant result was the difference in performance among UVA students in both the School of Engineering & Applied Sciences (SEAS) and the School of Architecture (SARC) as compared to students in the College of Arts & Sciences (CLAS). The regression model suggests that SARC students are at a significant disadvantage as compared to students in the CLAS. Architecture students at UVA probably would claim that the time-intensive nature of their curriculum, in particular relative to their liberal arts counterparts, forces them to trade-off the study of economics for course work in their professional school. This result also may be attributable to Architecture students having less previous exposure to analytical-intensive course work at the college level. On the other hand, Engineering students perform slightly better than comparable CLAS students. Students in the SEAS are expected to garner a solid background in science and math courses in their first year of study, and this foundation may be the cause for their strong performance in Econ 201.

We also analyzed the performance of students transferring from both two-year and four-year colleges against the general population of students who entered UVA from high school. Our results indicate that transfer students appear to slightly under-perform non-transfer students, but the results are not significant at the 95% confidence level. The

marginal effects calculation indicates that transfer students are no more than 0.1% likely (in absolute terms) to achieve any of the twelve possible letter grades than their non-transfer student peers.

Athletes in our study where subdivided by what sport they played. Men competing on the football and basketball teams were designated as high-profile athletes, since these sports demand an exceptional time commitment and command great fan appeal. This designation is not meant to diminish the efforts that other student-athletes devote to their sports; rather, the authors were interested in uncovering any performance differential across the two groups compared with non-athletes. Non-athletes at UVA out-performed both athlete distinctions in Econ 201. This result may be attributed to the amount of time and effort students are able to lend to their studies. High profile athletes were at a more significant disadvantage, being several percentage points less likely to achieve a grade in the A-range than other student-athletes.

The final demographic characteristics we examined were in-state students, i.e., students whose parents are residents of the Commonwealth of Virginia; "out-of-state" students; and legacy students, who are immediately related to an alumnus of UVA. The student population at the University of Virginia is comprised of two-thirds in-state students and one-third out-of-state or foreign students. Our analysis found that both in-state and legacy students were at a slight but statistically significant disadvantage as compared to their out-of-state counterparts.

The conventional wisdom is that out-of-state students are of a higher caliber because the admissions process is more competitive for this group. Further, the tuition for out-of-state students is three times that of in-state students. This may induce out-of-

state students to exert greater effort to ensure that their capital investment pays off. Legacy students are subject to more liberal admissions standards than other applicant pools. Those who apply from another state are given the benefit of being considered as an in-state student throughout the application process. However, legacy students pay tuition according to where they attended high school.

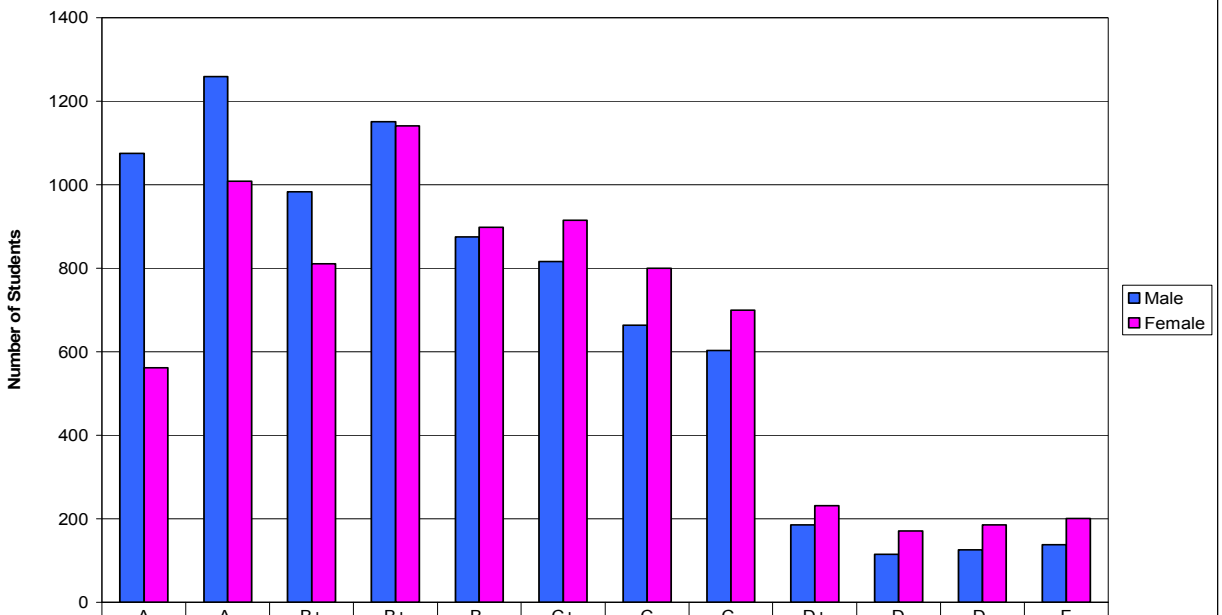
IX. Predicting Econ 201 Grades: Male-Female Differences

We now return to our analysis of the difference in performance between men and women. Other researchers have found that men perform better in economics courses than women, even when controlling for various measures of aptitude. Our study is no different. But the size of our database allows us to probe more extensively. In order to uncover the cause of the difference, we first compared the grade distribution of all students across gender (see Figure 1). The distributions are similar -- *except in the A grade range*. Men earned 1259 A minuses over the time-period while women earned only 1008. Men earned almost two times as many A's as females over the time period (1075 to 562 respectively). The greater number of males earning A's is not caused by a disproportionate enrollment: Econ 201 at UVA has been almost gender-nuetral (51% male, 49% female).

The ordered probit model indicates that the male grade variable is significant at the 99.9% level of confidence even when controlling for other demographic characteristics and pre-college achievement measures. The marginal effects calculation indicates that a male is 1.73% more likely to get an A- and 1.33% more likely to get an

A/A+ than a female. This result seems to indicate an upper-tail male premium may be the cause of the difference in performance between males and females.

Figure 1. Male-Female Distribution Comparison (N=15616)



	A	A-	B+	B+	B-	C+	C	C-	D+	D	D-	F
Male	1075	1259	983	1151	875	816	664	603	186	115	126	138
Female	562	1008	811	1141	898	915	800	700	232	171	186	201

Siegfried and Walstad (1990) review research on potential male-female performance variation due to possible differences in how males and females respond to different test formats. Early studies suggest that males perform better on multiple-choice examinations while females do better on essay examinations. But later research suggests this is not the case. Notwithstanding the inconclusive research on this subject, Siegfried and Walstad (1990, p. 150) recommend that the instructor "should hedge by using a variety of testing or assessments formats – multiple choice, essay, short-answer, problems and written work."

The class size in Econ 201 at UVA deters the use of "essays" and "written work" as components of the testing process. But the testing format in Econ 201 is somewhat

"hedged" and is not uniform throughout the course. During the semester, neither of the first two tests is "objective" (i.e., there are no true-false or multiple-choice questions). The format for the two mid-semester tests is "short answer," i.e., problem solving that requires brief written responses from the students. In order to standardize across Teaching Assistants (TAs) and to minimize grading time for TAs at the end of the semester, the final examination is entirely multiple-choice. The modest variety of testing formats obviously has not eliminated the male-female performance differential (but perhaps reduced it).

In their study of Wireless Interactive Teaching Systems cited earlier, Ball, Eckel, and Rojas (2006) found that first year students and females had the most significant positive test improvements in the presence of this classroom technology (they regard these as "groups that often struggle with introductory economics") (2006, p. 442).[23] The initial experiment with this kind of technology at UVA (fall 2006) was marked by student enthusiasm but marred by unreliable radio frequency equipment (clickers). Interactive teaching was put on hold. The Ball-Eckel-Rojas results, coupled with purported improvements in reliability, caused the equipment's return to the lecture hall in the fall of 2007.

X. Predicting Econ 201 Grades: Pre-College Performance Measure Results

We now turn our focus to evaluating the predictive value of students' pre-college performance measures as they relate to grades in Econ 201. It was found that all pre-college measures are statistically significant, positive predictors of success with a 99.9%

[23] They also report that teacher evaluations were higher in the experimental class using this technology.

level of confidence. While prior research suggests that a student's SAT Verbal score was the best forecaster of success in an economics course (see Fels and Siegfried, 1979), our research conforms to contemporary findings that Math scores are a better explanatory variable. For example, Ballard and Johnson (2004) found that a student's Math ACT score was a better predictor of success in the principles course than the English ACT score.

The marginal effect calculation for SAT Math scores implies that every point increase in a student's score makes a student .066% more likely to obtain an A/A+. Although this result is most likely non-linear, one could estimate that a hundred point increase in a student's score would make a student several percentage points more likely to obtain a top grade. Meanwhile, a point increase in a student's SAT Verbal score implies a student is only .033% more likely to receive an A/A+. Advanced standing hours also are a positive and significant factor in determining a student's final grade. This result is consistent with Brasfield, Harrison, and McCoy (1993, p. 99) who found that exposure to economics in high school positively affects performance in introductory micro and macroeconomics.

By analyzing a more limited database of 6,744 students who have taken Econ 201 since 1997, we were able to test the predictive value of a student's high school GPA (see Table 5 and Table 6 in the Appendix for full results). We performed an almost identical ordered probit regression model as outlined by Equation (14), the only difference being the inclusion of an extra explanatory variable for a student's high school GPA (defined as $\beta_{21}\,\text{HS GPA}_i$). The model indicates that each high school grade point increase implies a

student is 10% more likely to obtain an A- and 7% more likely to receive an A/A+ in Elzinga's introductory course.

XI. Using Econ 201 Grades to Predict Future Success

The final part of our analysis uses an ordered probit model (virtually identical to the one used to predict a student's grade in Econ 201) to examine how the accumulation of human capital in an introductory economics course can predict performance in more advanced economics courses. The model uses all demographic characteristics, pre-college achievement measures (besides year of study and high school GPA), and the student's grade in Elzinga's introductory microeconomics course to predict his or her performance in both intermediate micro and macroeconomics.

Our model indicates that performance in introductory microeconomics is positively correlated with performance in both intermediate courses. The marginal effect calculation (see Table 7 in the Appendix) indicates that for every grade point increase in a student's final grade in Econ 201, he or she is 7% more likely to obtain an A- and 14% more likely to obtain an A/A+ in intermediate microeconomics. The findings are similar for intermediate macroeconomics, which indicate that every grade point increase in Econ 201 makes a student 7% more likely to obtain an A- and 15% more likely to obtain an A/A+.

XII. Conclusions

The analysis of almost 16,000 UVA students in the principles course does nothing to confirm or refute Stigler's sobering claim that the principles course in economics

generates little knowledge that is retained five years hence. Moreover, there are few, if any, hard and fast lessons that can be drawn from the instruction of these students over more than twenty years. Finally, what happened at the University of Virginia may or may not fit the experience of other institutions. But there are lessons nonetheless.

First, economics, at least at the principles level, is not a subject that is out of reach for any student group. Liberal arts students can access introductory economics on a par with engineering students. Architecture students are slightly weaker performers but can compete in the same course. While years-in-rank are associated with better grade performance in the micro principles course, the difference is not striking and does not suggest bifurcating the principles course or excluding first year students. The male-female performance gap is the most striking finding in our study, and the disparity is a reminder that teacher style, lecture examples, and the kinds of tests used must not be tilted to favor male learning patterns or styles.

In the face of Stigler's assertion, revealed preference offers teachers of economic principles some consolation if not significant affirmation. The simple fact that so many students continue to enroll in both micro and macro principles suggests that the course has positive expected value. In fact, we can confirm that if students invest the necessary energy to succeed in a principles course, they are significantly more likely to find the same success in future courses. Indeed, Stanca (2006) surveys past studies and presents new data that should provoke professors in the introductory course to breathe a sigh of relief. Stanca writes: "Can we conclude then that we, as academics, are doing something useful for student learning? According to the results of this study, the answer is 'Yes.'"

Most instructors of economic principles want to teach students to "think like an economist" and be able "to analyze real world policy issues through the lens of economic analysis." These are laudable objectives. This paper is in the grain of many others that address how best to meet these objectives and how best to measure whether they are being met.

XIII. Appendix

Table 4. Predicting Econ 201 Grade – Marginal Effects Estimation (n=15616)

	F	D-	D	D+	C-	C	C+	B-	B	B+	A-	A/A+
Demographic Characteristics												
First Year	0.6124%	0.7290%	0.7100%	1.0500%	3.0122%	2.5815%	1.8060%	0.4580%	-1.3440%	-2.4220%	-4.2390%	-2.9540%
Second Year	0.2960%	0.3750%	0.3760%	0.5729%	1.7266%	1.5873%	1.2300%	0.4690%	-0.5820%	-1.3699%	-2.6470%	-2.0360%
Third Year	0.2347%	0.2916%	0.2897%	0.4365%	1.2933%	1.1601%	0.8677%	0.2925%	-0.4930%	-1.0347%	-1.9210%	-1.4170%
Male	-0.1938%	-0.2458%	-0.2467%	-0.3750%	-1.1313%	-1.0398%	-0.8050%	-0.3060%	0.3830%	0.8980%	1.7330%	1.3286%
African American	0.9537%	1.0770%	1.0208%	1.4750%	4.0520%	3.2610%	2.0600%	0.2410%	-2.1260%	-3.2720%	-5.3140%	-3.4290%
Asian American	0.3640%	0.4410%	0.4320%	0.6440%	1.8680%	1.6260%	1.1630%	0.3276%	-0.7980%	-1.5030%	-2.6750%	-1.8910%
Native American	0.6250%	0.7269%	0.6970%	1.0200%	2.8590%	2.3682%	1.5669%	0.2813%	-1.4120%	-2.3100%	-3.8620%	-2.5610%
Hispanic American	0.4891%	0.5790%	0.5610%	0.8279%	2.3570%	1.9972%	1.3700%	0.3119%	-1.0960%	-1.9020%	-3.2670%	-2.2280%
Non-Resident	-0.3820%	-0.5255%	-0.5510%	-0.8710%	-2.8250%	-2.8750%	-2.5604%	-1.3970%	0.3025%	2.0890%	4.9618%	4.6350%
School of Engineering	-0.0512%	-0.0655%	-0.0661%	-0.1010%	-0.3060%	-0.2849%	-0.2238%	-0.0889%	0.0986%	0.2430%	0.4760%	0.3700%
School of Architecture	1.5350%	1.6320%	1.5000%	2.1130%	5.5360%	4.1480%	2.3030%	-0.1640%	-3.2960%	-4.4650%	-6.7719%	-4.0700%
In-State	0.0992%	0.1266%	0.1276%	0.1940%	0.5900%	0.5460%	0.4280%	0.1680%	-0.1920%	-0.4680%	-0.9135%	-0.7080%
Legacy	0.2670%	0.3290%	0.3253%	0.4879%	1.4330%	1.2697%	0.9320%	0.2930%	-0.5746%	-1.1490%	-2.0960%	-1.5180%
High Profile Athlete	1.2720%	1.3810%	1.2820%	1.8224%	4.8490%	3.7199%	2.1570%	-0.0125%	-2.7880%	-3.9157%	-6.0560%	-3.7110%
Other Athlete	0.2950%	0.3588%	0.3525%	0.5258%	1.5290%	1.3360%	0.9600%	0.2760%	-0.6460%	-1.2303%	-2.1980%	-1.5592%
Community College Transfer	0.0040%	0.0050%	0.0050%	0.0077%	0.0235%	0.0216%	0.0167%	0.0064%	-0.0080%	-0.0186%	-0.0360%	-0.0275%
Four Year College Transfer	0.0143%	0.0182%	0.0182%	0.0278%	0.0837%	0.0768%	0.0590%	0.0223%	-0.0287%	-0.0666%	-0.1280%	-0.0976%
Prior Performance Measures												
SAT Verbal	-0.0048%	-0.0061%	-0.0060%	-0.0093%	-0.0280%	-0.0257%	-0.0200%	-0.0076%	0.0095%	0.0223%	0.0430%	0.0330%
SAT Math	-0.0097%	-0.0122%	-0.0123%	-0.0188%	-0.0567%	-0.0522%	-0.0406%	-0.0154%	0.0192%	0.0451%	0.0871%	0.0667%
Advanced Standing Hours	-0.033%	-0.042%	-0.043%	-0.065%	-0.195%	-0.180%	-0.140%	-0.053%	0.066%	0.155%	0.300%	0.230%

Table 5. Predicting Econ 201 Grade with HS GPA Ordered Probit Results (n=6744)

	Coefficients	Standard Error	P-Value
Control Variables			
Year	-0.044	0.0047	0.000
Demographic Characteristics			
First Year	-0.129	0.0638	0.043
Second Year	-0.018	0.0589	0.766
Third Year	-0.055	0.0620	0.371
Male	0.193	0.0266	0.000
African American	-0.225	0.0636	0.000
Asian American	-0.197	0.0411	0.000
Native American	0.043	0.2542	0.866
Hispanic American	-0.093	0.0702	0.187
Non-Resident	0.403	0.0946	0.000
School of Engineering	-0.020	0.0425	0.642
School of Architecture	-0.509	0.1035	0.000
In-State	-0.046	0.0302	0.127
Legacy	-0.062	0.0349	0.074
High Profile Athlete	-0.025	0.2163	0.909
Other Athlete	-0.068	0.0689	0.324
Community College Transfer	0.640	0.4136	0.122
Four Year College Transfer	0.231	0.2453	0.363
Prior Performance Measures			
SAT Verbal	0.003	0.0002	0.000
SAT Math	0.005	0.0002	0.000
Advanced Standing Hours	0.020	0.0015	0.000
High School GPA	0.528	0.0371	0.000
Threshold Values			
μ_1	-83.27		
μ_2	-82.90		
μ_3	-82.67		
μ_4	-82.46		
μ_5	-81.95		
μ_6	-81.41		
μ_7	-80.94		
μ_8	-80.57		
μ_9	-80.17		
μ_{10}	-79.76		
μ_{11}	-78.96		
Scaled R^2	0.10		

Table 6. Marginal Effect of High School GPA on a Student's Econ 201 Grade

F	-0.422%
D-	-0.668%
D	-0.756%
D+	-1.017%
C-	-4.122%
C	-6.485%
C+	-5.318%
B-	-2.180%
B	0.797%
B+	3.696%
A-	9.695%
A/A+	6.781%

Table 7. Predicting Further Success - Marginal Effect of Econ 201 Grade

	Econ 301 Grade	Econ 302 Grade
F	-0.032%	-0.003%
D-	-0.135%	-0.408%
D	-0.973%	-1.199%
D+	-0.853%	-1.125%
C-	-3.070%	-3.447%
C	-7.819%	-6.242%
C+	-4.741%	-4.580%
B-	-4.982%	-5.545%
B	-2.177%	-2.220%
B+	3.910%	3.247%
A-	6.791%	6.327%
A/A+	14.077%	15.196%

XIV. References

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