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PETER KENNEDY, Section Editor

The Determinants of Success in University Introductory Economics Courses

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This article is concerned with the factors that determine a student's success in introductory university economics courses. The central focus of our research was the extent to which it is possible to predict success in these university courses based on information about prior achievement and background, as indicated by the student's record in the final year of high school. Although there is, of course, intrinsic interest in the determinants of success in postsecondary school education, several other issues led us to consider this research topic. Considerable resources are involved in the provision of first-year economics courses at a large university, both for the demanders and suppliers of such a service. For students, wasted time is associated with the unsatisfactory experiences of noncompletion, failure, or insufficiently high grades to proceed to further study of economics. The importance of this problem is evident in Table 1, which contains a sample of attrition rates in introductory economics at the University of Toronto. Students who fail, drop out, or do not obtain at least a C grade are prevented from further study in economics. Approximately 60 percent of enrolled students find themselves in this unhappy state.[1] On the supply side, fully 35 percent of the Depart-

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TABLE 1
Economics 100 Attrition Rates

	St. George campus		Erindale campus	
	Winter '88	Summer '89	Winter '88	Summer '89
Initial enrollment	2,467	515	813	176
Percentage dropping course				
First term[a]	15		12	
Second term	18	35	30	30
Percentage fail	10	10	14	13
Percentage achieving a grade of D	14	17	16	16
Percentage unable to continue in economics (1) + (2) + (3) + (4)	57	62	72	59

[a]There was no distinction between first and second term in the summer session.

ment of Economics teaching assistants are allocated to introductory economics.[2] If characteristics of incoming students are reliable predictors of their ultimate fate in the introductory economics course, students and departmental resources could be more efficiently allocated by excluding, ex ante, students with low probabilities of success.

A number of previous studies have examined the impact of a range of measures of high school performance on student performance in introductory economics courses (Harbury and Szreter 1968; Crowley and Wilton 1974; Reid 1983; Bonello, Swartz, and Davisson 1984; Dagenais 1986; Lumsden and Scott 1987; Myatt and Waddell 1990). Several features distinguish our research from these previous studies. First, we used a very large sample drawn from one of the largest universities in North America. Second, we included a broader range of variables that controlled for prior background, achievement level, and demographics than is typically the case. Third, we analyzed the decision to drop the course during the year, a decision that is of quantitative importance (Table 1) and that has not previously been analyzed. Fourth, we considered in more detail than is usually the case the role of gender as a factor influencing a student's achievement level in introductory economics.

In this study, we analyzed the effects on performance of a summary measure of a student's high school record as a senior (for Ontario this is the grade 13 average grade), as well as measures of high school background and achievement in three mathematics subjects (algebra, calculus, and functions and relations), English, and economics. The importance of prior background and achievement found in most earlier studies was also characteristic of this study. We also obtained information on the gender effect in economic education; our findings corroborate the usual observation that men's achievement level is higher than women's (Crowley and Wilton 1974; Lumsden and Scott 1987; Heath 1989; Myatt and Waddell 1990).[3] The effects of student vintage (number of years spent at university at the time the course was taken) and age were also analyzed.[4]

THE DATA

The data that we used in this study were drawn from a sample of students at the University of Toronto who were enrolled in the introductory economics course (ECO 100). ECO 100 is a two-semester course in principles of economics that covers both microeconomics and macroeconomics and that must be taken as a complete year-long unit (i.e., single-semester credit is not possible). The University of Toronto is one of the six largest (in terms of student enrollment) universities in North America. In a typical year, approximately 4,500 students enroll in ECO 100 in winter or summer sessions on one of the university's three campuses (the downtown St. George campus and the suburban Erindale and Scarborough campuses). ECO 100 is taught in sections of 450 students on the downtown campus and 100 to 250 students on the suburban campuses.[5]

The data available for each enrolled student consisted of the grade obtained in ECO 100 (if completed), gender, age, year of study, campus location, and various indicators of high school performance as a senior. The indicators chosen for inclusion were the grade 13 average grade and grade 13 grades in algebra, calculus, functions and relations, economics, and English. In our view, achievement in these subjects is most likely to be correlated with success in introductory economics. Not all students sampled had recorded grades in each of the five subjects, for two reasons. First, with the exception of English, all of the other subjects are optional in grade 13. Second, a student's Faculty of Arts and Science record contains only the grade 13 average and the final grades in the student's top six subjects.[6] Largely through lack of data on prior background and achievement, out-of-province students were omitted from this study. It is not likely that this omission generated selectivity problems.

The total sample consisted of 6,718 students who were enrolled in ECO 100 (Table 2). Our primary sample contained 3,898 students from Ontario high schools who had completed ECO 100 during the 1987 and 1988 winter sessions and the 1988 and 1989 summer sessions on the St. George and Erindale campuses. (Scarborough college is not part of the Faculty of Arts and Science and was not included.) A unique feature of our data set was that for the 1988 winter session we had detailed information on the characteristics of students who had dropped the course during the session. Because 30 to 40 percent of initially enrolled students do not complete the course, it is important to analyze the dropping decision. In a later section, we provide logit estimates of the dropping decision for a sample of 1,885 students from Ontario high schools who had enrolled in ECO 100.

For this 1988 sample, the data also contained each student's final grades in Commerce 120H (introductory business) and Mathematics 133 (calculus and linear algebra). We used this additional information in our analysis of the effect of gender on performance in ECO 100.

ESTIMATION RESULTS

We used ordinary least squares to regress the ECO 100 final grade on the student characteristics listed on the left-hand side of Table 3. The sample of 3,898

TABLE 2
Various Subsample Characteristics, First-Year Economics (ECO 100)

Characteristic	Session[a] '87 W	'88 S	'88 W	'89 S	Total
St. George campus					
Number enrolled[b]	1,641	509	2,467	515	5,132
Number completed	1,494	358	1,653	336	3,841
Number with grade 13	1,275	345	1,885	365	3,870
Grade 13 average	81.7	80.8	81.1	81.1	81.2
	(0.2)	(0.4)	(0.3)	(0.3)	(0.1)
Proportion male	0.54	0.54	0.52	0.54	0.53
	(0.01)	(0.02)	(0.02)	(0.02)	(0.01)
Mean grade in ECO 100	65.7	67.4	63.1	61.2	64.3
	(0.3)	(0.7)	(0.4)	(0.8)	(0.2)
Erindale campus					
Number enrolled	477	120	813	176	1,586
Number completed	435	78	476	123	1,112
Number with grade 13	377	75	639	114	1,205
Grade 13 average	74.0	72.9	73.0	72.6	73.3
	(0.3)	(0.7)	(0.3)	(0.6)	(0.2)
Proportion male	0.58	0.58	0.55	0.55	0.56
	(0.02)	(0.05)	(0.02)	(0.04)	(0.01)
Mean grade in ECO 100	60.0	64.6	57.4	61.3	59.3
	(0.8)	(2.1)	(0.7)	(1.5)	(0.5)

Note: Standard errors are in parentheses.
[a]Sessions are '87 winter, '88 summer, '88 winter, and '89 summer. Only the '88 winter and '89 summer sessions had complete data on students who dropped ECO 100.
[b]The enrollment for '87 W numbers were not directly comparable to the '88 W session because of a change in the recording procedures. For the St. George campus, a more comparable (and accurate) figure for the number enrolled in '87 W was 2,306.

contained all students who had complete Ontario high school records. To assess potential biases in estimating with this sample, we computed the regression for the larger sample of 6,718 for the simple specification (with no controls for high school performance). The results (not shown) were similar to those presented in column 4 of Table 3.

The specification presented in column 1 is the most general specification we considered. This specification included as explanatory variables demographic variables (gender, age, and vintage), session and campus control variables, and measures of academic background and prior achievement (grade 13 average, indicators of which courses were taken in grade 13, and grades achieved in selected grade 13 courses). Not surprisingly, the more experienced a student, the better the performance in ECO 100. The more years of university under a student's belt, presumably the better able the student is to "play the game" and contend with the difficulties and responsibilities of university course work. Other studies (e.g., Bonello, Swartz, and Davisson 1984) have suggested that maturity helps one's performance in economics. The vintage effect would seem consistent with this. However, the coefficient on age went against this simple explanation as there appeared to be a negative age effect, controlling for vintage, which persisted throughout the different regressions. The age-squared term implies that at age 26,

TABLE 3
Determinants of Grade in ECO 100

	Full specification		Exclude course grade		Exclude all course effects		Exclude all high school effects	
Intercept	16.06	(14.55)	6.05	(14.22)	14.44	(14.28)	143.43*	(15.95)
Male	3.30*	(0.39)	3.36*	(0.39)	3.50*	(0.39)	3.12*	(0.45)
Erindale	3.19*	(0.52)	3.15*	(0.52)	3.32*	(0.52)	−5.05*	(0.54)
88 summer session	2.77*	(0.81)	2.79*	(0.81)	2.82*	(0.81)	2.09*	(0.94)
88 winter session	−2.61*	(0.42)	−2.59*	(0.42)	−2.46*	(0.42)	−2.53*	(0.48)
89 summer session	−2.92*	(0.78)	−2.82*	(0.78)	−2.73*	(0.78)	−3.14*	(0.90)
Sophomore	1.33*	(0.58)	1.23*	(0.58)	1.29*	(0.58)	1.18*	(0.67)
Junior	2.16*	(0.85)	2.11*	(0.85)	2.09*	(0.84)	6.03*	(0.96)
Senior	3.09*	(1.13)	3.04*	(1.14)	3.08*	(1.13)	6.23*	(1.30)
Year 5	4.29*	(1.62)	4.18*	(1.62)	4.85*	(1.61)	6.59*	(1.86)
Year 6	6.78*	(1.80)	6.51*	(1.80)	6.96*	(1.79)	6.96*	(2.07)
Age	−3.26*	(1.26)	−3.17*	(1.26)	−3.52*	(1.27)	−6.65*	(1.46)
Age squared	0.06*	(0.03)	0.06*	(0.03)	0.07*	(0.03)	0.13*	(0.03)
Grade 13 average	1.00*	(0.06)	1.10*	(0.03)	1.11*	(0.03)		
Algebra indicator	−3.85	(2.48)	0.22	(0.42)				
Calculus indicator	−0.44	(2.03)	3.84*	(0.50)				
Economics indicator	−10.91*	(3.30)	0.64	(0.42)				
English indicator	4.90*	(2.24)	1.15*	(0.48)				
Functions indicator	−1.93	(2.28)	−0.12	(0.42)				
Algebra grade	0.05	(0.03)						
Calculus grade	0.05	(0.03)						
Economics grade	0.14*	(0.04)						
English grade	−0.05	(0.03)						
Functions grade	0.02	(0.03)						
R squared	.032		0.31		0.30		0.07	
F test for marg'l exclusions[a]			4.7	(0.000)	13.9	(0.000)	1289.2	(0.000)

Notes: Dependent variable is grade in ECO 100. Sample size = 3,898. Standard errors are in parentheses, unless otherwise noted. *Indicates significance at the 5% level.
[a]*F* test for marginal exclusion is the *F* test of the null hypothesis that the variables excluded between column *n* + 1 and *n* are jointly equal to zero. *P* values are indicated in parentheses.

age begins to have a positive effect. There were significant differences in average performance across sessions and campuses.[7]

Perhaps the most interesting and problematic result was the estimate of the gender coefficient. This estimate implied a male grade premium of 3.3 percentage points. This result was very robust to changes in specification, as demonstrated below. The existence of a male premium has been noted in other studies of the relationship between gender and performance in economics (Crowley and Wilton 1974; Lumsden and Scott 1987; Heath 1989; Myatt and Waddell 1990; see also note 3). This issue will be considered in a following section.

The central focus of our research was on the ability to predict success with information on prior achievement and background as indicated by high school performance. The grade 13 average coefficient was equal to 1.00, with a very small standard error. Thus, each 1 percentage point increase in a student's grade 13 average was associated with an increase in the final grade in ECO 100 of 1 percentage point. This particular result was robust to changes in the specification (columns 2 and 3, Table 3). The grade 13 grade by itself had a high explanatory power with respect to the ECO 100 grade (compare columns 3 and 4, Table 3). When this variable was removed, R^2 decreased from .30 to .07.

Although a positive effect of high school average or percentile rank on performance has been noted in previous studies (Reid 1983; Bonello, Swartz, and Davisson 1984; Myatt and Waddell 1990), we found the high explanatory power of the grade 13 average grade to be surprising. First, the grade 13 average is a midyear result used for admission purposes, rather than the student's actual final average. Second, Ontario has no uniform entrance examinations, and the variation in quality of instruction and grading practices across high schools might be expected to insert substantial noise into the relationship between performance in high school and performance in introductory university courses. To the extent that economics is typical, this presumption is apparently untrue. (As will be discussed later, the same strong relationship exists with introductory business and mathematics courses.)

The last group of variables investigated whether a student's high school background, as represented by the mix of courses taken in the senior year and the grades obtained in those courses, affects success in ECO 100. The regression results (column 1, Table 3) contain dummy variables that indicate whether algebra, calculus, functions and relations, economics, and English were taken during the senior year in high school as well as measures of the grades obtained.[8] This particular functional form generated coefficients that could best be interpreted in terms of threshold effects. Except for English, each course had a negative intercept in its effect on ECO 100 performance and a positive slope. Calculus and economics exhibited statistically significant slope effects.

The threshold levels (and their standard errors) for each course that corresponded to these coefficient estimates are shown in Table 4. The threshold grade is the grade at which taking the course has a positive effect on ECO 100 performance. The value of the F test for inclusion of each pair of course variables is also given in Table 4. For algebra and functions and relations, the F test indicated joint insignificance of the coefficients for these courses. Calculus had the strong-

TABLE 4
Tests of Effects of Grade 13 Courses Based on Regression (1) from Table 3

Course	F test[a]	Threshold grade[b] (standard error)
Algebra	1.21	80.59 (9.39)
Calculus	28.97	8.39 (34.2)
Economics	7.48	76.04 (3.18)
English	4.53	99.06 (17.1)
Functions	0.42	90.59 (23.3)

[a] F test for inclusion of the two variables corresponding to each course. 5% critical level for F (2,N − K) is 3.00 where N − K = 3,898 − 24 = 3,874.
[b] Threshold grade is the grade at which taking a course has zero effect on ECO 100 grade. Depending on the sign of the coefficient on course grade, the effect of taking the course increases or decreases after the threshold.

est effect, in terms of both the F test and the threshold grade. The F-test statistic, at 28.97, was the highest (by far) of all the F tests. The threshold grade of 8.4 was not meaningful because it was far below the minimum reported calculus grade in the sample. It is clear that taking calculus had an unambiguous beneficial effect on a student's ECO 100 grade.[9] This result is not surprising given the fact that the testing procedure emphasizes analytical ability (see note 5).

In the case of economics, the data indicated that having taken economics in high school did significantly improve performance in ECO 100, but only if a student had obtained a grade of 76 percent (a "middle B") or higher.[10]

The one counter-intuitive result related to English. The negative coefficient for the English grade implies that the better one does in English, the worse one will do in ECO 100, and this effect occurred at virtually all levels of the English grade. Although the coefficients for English were jointly statistically significant, the coefficient for the English grade was not significant (at the 5 percent level).[11]

We next investigated the possibility that a more parsimonious specification might not be rejected by the data (columns 2 to 4, Table 3). We first restricted the specification to exclude grade effects. When the course performance variables were excluded, R^2 decreased only marginally (from .32 to .31), but the excluded variables were statistically significant. Similarly, conditional on the exclusion of the grades variables, the further exclusion of the course indicator variables did not change R^2 much (a decrease from .31 to .30), but the excluded variables were once again jointly statistically significant. Finally, as noted above, the marginal exclusion of the grade 13 variable was decisively rejected (F statistic of 1289.2), demonstrating its key role in explaining the ECO 100 grade.

INTERPRETATIONS OF THE RESULTS

Now that we have established some of the basic correlations in the data, let us attempt to interpret the coefficients, or at least rule out some of the more obvious misinterpretations. High school students are not randomly assigned to treatment and control groups for the administration of doses of high school courses. Students have considerable leeway in their selections of courses. To some degree, then, the portfolio of courses taken by students will reflect their abilities and tastes. To the extent that these abilities and tastes are not fully accounted for by the course variables and the grade 13 average, omitted-variable bias will affect the course coefficients if we wish to interpret them as genuine effects of taking a particular subject. Effort is another omitted variable that can cause interpretation difficulties.

Student choice of high school courses is endogenous, and this choice will depend primarily on unobserved ability and tastes, as well as on the expected college major. A further problem is caused by the fact that we observe only the student's top six courses (by grade). For example, a student who did poorly in calculus will not report the calculus grade if she or he has six other grades that are higher. Therefore, as noted earlier, the definition of the course dummy variables must be qualified along the lines of "took calculus and did relatively well in it." The negative effect of the English grade (Table 3) may therefore reflect, not some inherent disadvantage for the artistically talented, but rather a negative effect for those students who did well in English at the expense of doing well in calculus. To gain some insight into which courses tended to be reported together, we show in Table 5 who took which courses, by course taken. For example, based on high school average, the students who took economics were the worst students. This could explain the relatively high threshold needed to attain a positive effect. In addition, students who took economics took less algebra and calculus than any other group of students. Of course, the direct effects of which courses were taken were controlled for in the regression. What is clear from this exercise is that students with different qualities take different portfolios of courses, and to the degree that these qualities are unmeasured, they will pile up on the course effects and perhaps other effects such as the gender effect.[12]

In addition to endogeneity of the high school courses selected by students, we must consider another statistical problem with the regressions of Table 3. Of the students who initially enroll in ECO 100, 30 to 40 percent do not complete the course (Table 1), dropping it before attaining a final grade. Students may choose to drop the course for several reasons, ranging from a dislike of economics, its instructors, the way the course fits into their timetables, what their friends are

TABLE 5
Percentage Who Take Which Courses

If one takes:	Take Alg.	Take Calc.	Take Eco.	Take Eng.	Take Func.	G 13 avg.
Algebra	100.0	85.4	24.5	78.4	63.8	81.7
Calculus	44.9	100.0	36.5	79.4	71.9	79.6
Economics	26.3	74.7	100.0	81.2	66.9	78.1
English	40.8	78.6	39.2	100.0	68.1	79.3
Functions	39.3	84.2	38.3	80.6	100.0	79.0

taking, or their performances on early tests. There was no information in our data set that would permit a comprehensive analysis of the dropping decision. Nor did we believe that plausible selectivity corrections could be made to the grades equation, because no reasonable variables were available to us that could be excluded from either the dropping or the grade equation.[13] What are the likely biases of looking at this restricted sample? If students drop courses on the basis of their anticipated grade, then low-ability students (ceteris paribus) will tend to drop the course. To the degree that such students also have low grade 13 grades, we will understate the effect of grade 13 grades on performance in ECO 100 (most low-average grade 13 students remaining in our sample with completed ECO 100 would have high unobserved ability). The potential biases on the other coefficients will depend on the relationship between the dropping decision, unobserved ability, and the variable in question. However, given this selectivity effect, and also given that drops are costly, both in terms of lost student time and the opportunity cost of a classroom chair, we examined the drop decision in some detail. To do this, we focused on one campus and one session, the St. George campus for the winter 1988 session. For this session, we knew, for each enrolled student, whether he or she dropped the course in the first semester (early), dropped the course in the second semester (late), or completed the course. A student may drop the course any time before the third week in February (about midway through the second semester) without academic penalty (no grade will be recorded).

For our most general model, we specified the student's choice decision as a sequential trivariate logit model, with the choices being drop early, drop late, or complete the course.[14] We began, however, by considering the simpler bivariate choice—drop the course or complete it. The logit estimates of the effects of our set of explanatory variables on whether or not a student drops the course are presented in Table 6 (column 1). The data indicated that men were less likely to drop the course. This could reflect either tastes or performance. The older the vintage (the more experienced the student), the more likely the student was to drop the course. It may be the case that older students were more careful in choosing courses that would improve their grade point averages and in dropping courses when they appeared likely to damage their average. It was also clear that doing well in grade 13 and taking any of the courses analyzed improved the likelihood of completing ECO 100. Taking calculus and economics went the furthest toward contributing to a student's completion of ECO 100. The likelihood ratio tests for inclusion of the five courses indicated that, as a group, they were statistically significant predictors of whether or not a student drops ECO 100. It is worth noting that there were several omitted courses (history, geography, and French, for example) in the implied omitted category.

In Table 6 (columns 2 and 3) we present results of the sequential logit model. We chose the early and late dropping categories because of their different implications for a student's waste of time resources. Presumably a student who dropped sooner was a student who quickly developed a dislike for the subject, or quickly discovered a relative (to other courses) lack of talent. A student who dropped in the second semester was the more persistent student who was willing to absorb the loss of another semester of course work in a futile attempt to complete ECO 100.

TABLE 6
Determinants of Dropping ECO 100, Logit Estimation

	Logit coefficients			
	Logit[a]	Sequential logit[b]		Logit[c]
	Pooled drop	Drop 1st semester	Drop 2d semester	Fail to qualify
Constant	0.524	−1.840	0.032	5.886
	(3.698)	(4.858)	(5.058)	(3.570)
Male	−0.232	−0.175	−0.269	−0.224
	(0.110)	(0.149)	(0.140)	(0.104)
Sophomore	0.439	0.726	0.137	−0.049
	(0.157)	(0.201)	(0.210)	(0.156)
Junior	0.507	0.814	0.132	−0.153
	(0.242)	(0.298)	(0.341)	(0.240)
Senior	0.331	0.258	0.290	−0.465
	(0.332)	(0.444)	(0.423)	(0.324)
Year 5	0.945	0.810	0.878	0.119
	(0.415)	(0.513)	(0.529)	(0.434)
Year 6	0.663	−0.204	1.066	−0.830
	(0.507)	(0.711)	(0.620)	(0.520)
Age	0.246	−0.021	0.511	0.423
	(0.321)	(0.414)	(0.449)	(0.312)
Age squared	−0.005	0.001	−0.012	−0.007
	(0.007)	(0.009)	(0.010)	(0.007)
Grade 13 average	−0.043	0.007	−0.079	−0.123
	(0.009)	(0.012)	(0.012)	(0.009)
Algebra indicator[d]	−0.266	−0.143	−0.318	−0.052
	(0.121)	(0.162)	(0.156)	(0.112)
Calculus indicator	−0.505	−0.764	−0.247	−0.722
	(0.126)	(0.160)	(0.164)	(0.129)
Economics indicator	−0.421	−0.630	−0.220	−0.342
	(0.119)	(0.169)	(0.149)	(0.111)
English indicator	−0.224	0.027	−0.351	−0.282
	(0.135)	(0.184)	(0.169)	(0.133)
Functions indicator	−0.101	−0.283	0.019	−0.111
	(0.115)	(0.151)	(0.151)	(0.111)
− Log likelihood	1,046.4	665.4	699.3	1,130.2

Notes: Sample size = 1,885. Standard errors are in parentheses.
[a]Pooled drop is the simple logit, estimating determinants of the drop-don't drop decision.
[b]The sequential logit treats the drop decision sequentially: drop first semester, or *conditional* on not having dropped in the first semester, estimating the determinants of dropping in the second semester.
[c]The fail to qualify logit summarizes the grades earned and dropping equations, by combining information on grades earned and completion of the course. Students are deemed to qualify if they are eligible for future economics courses: i.e., a grade of C (60 percent) or higher. 882 students (47 percent of the sample) were successful.
[d]The χ^2 tests for exclusion of the levels of grades (in addition to the indicators) are 1.8, 3.2, and 2.0 for each of the logit equations above. Under the null hypothesis that these variables can be excluded, the test statistics are distributed $\chi^2(5)$, so the null is accepted.

The empirical results (Table 6, columns 2 and 3) support the hypothesis that the two types of dropping were distinct in the sense that the variables that influenced the drop decision did so differently in the two semesters. The key difference was the role of the grade 13 average. Students who did well in grade 13 were equally as likely as students of lesser achievement to drop ECO 100 in the first semester. However, they were not as likely to drop in the second semester. Another interesting pattern occurred for students who took high school economics. They had a much lower probability of dropping the course during the first semester than the second semester, ceteris paribus. Because the second-semester coefficient was not statistically significant, the hypothesis that students who had taken high school economics were as likely to drop the course during the second semester as students who had not taken high school economics could not be rejected. Calculus exhibited the same semester pattern as economics—the effect of having taken high school calculus in reducing the probability of dropping ECO 100 was much greater in the first semester. Students who were in their sophomore or junior years were more likely to drop sooner: they did not stick around if they saw the handwriting on the wall.

We present a summary measure of success in ECO 100 in column 4 of Table 6. Only students who achieve 60 percent (C–) or higher can take subsequent courses in economics. From a resource allocation perspective, there would be a high return if one could predict success based on these high school characteristics, rather than wasting both student and faculty resources. We thus added those students who completed the course with a D or F to those who dropped and labeled them "failed to qualify" for future studies. Not surprisingly, the coefficients reflected (and summarized) the findings of both the grade regressions and the dropping logits. High school performance and math background were significant predictors of success, and women were less likely to qualify to proceed in economics.

The logit coefficients, in contrast to the coefficients in a linear regression, did not directly provide a sense of the quantitative magnitudes of the effects on the dropping decision of changes in the explanatory variables. Determination of these magnitudes was complicated by the large number of dummy variables in the logit equations, which rendered an exhaustive discrete set of comparisons unfeasible. A set of interesting comparisons are presented in Table 7 to provide the reader with a feel for the magnitudes involved. We compared the dropping probabilities for two individuals, both of whom were 18-year-old first-year women who took English but not algebra or functions and relations in high school.[15] We were interested in the effects of taking calculus and/or economics in high school, and the effects of a high grade 13 average as compared with a low grade 13 average. If one matches up the various columns in Table 7, various differential probabilities can be calculated.

We considered first the implications from the pooled bivariate model. A comparison of columns 1 and 2 (Table 7) implies that the student described above who also obtained the sample mean grade 13 average and did not take calculus would have had a 9-percentage point lower probability of dropping ECO 100 if she had taken high school economics (.293 to .387). A student who took high school calculus and economics would have had an 8-percentage point lower probability of dropping than a student who took only economics (column 4 minus column 2). A student who had taken both economics and calculus would have a 19-percentage point lower probability of dropping than a student who took neither of these subjects (column 4 minus column 1), so the effects were almost additive. Consider finally two students at extreme ends of background and overall ability. The first

TABLE 7

Quantitative Impact of the Exogenous Variables on the Probability of Dropping ECO 100 Based on the Estimated Coefficients from Table 6

Student high school background	Mean grade 13 average				No calculus or economics		Both calculus and economics	
	No calculus or economics	Economics only	Calculus only	Both economics and calculus	High grade 13 average	Low grade 13 average	High grade 13 average	Low grade 13 average
Variable								
Vintage	Year 1	Year 1	Year 1	Year 1	Year 1	Year 1	Year 1	Year 1
Age	18	18	18	18	18	18	18	18
Sex	female	female	female	female	female	female	female	female
Grade 13 grade	mean	mean	mean	mean	90%	70%	90%	70%
Took algebra	No	No	No	No	No	No	No	No
Took functions	No	No	No	No	No	No	No	No
Took English	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Took calculus	No	No	Yes	Yes	No	No	Yes	Yes
Took economics	No	Yes	No	Yes	No	No	Yes	Yes
Prob. of dropping								
Pooled	0.387	0.293	0.276	0.200	0.305	0.508	0.118	0.238
1st semester	0.237	0.142	0.126	0.071	0.248	0.222	0.066	0.058
2nd semester	0.198	0.165	0.161	0.134	0.112	0.379	0.054	0.217

Note: Sample mean of grade 13 grade is 86.4 percent.

student took calculus and economics in high school and had a grade 13 average of 90 percent. The second student took neither calculus nor economics and had a grade 13 average of 70 percent. Comparing columns 6 and 7, we see that the first student would have had a 39-percentage point lower probability of dropping ECO 100 than the second student.

We now consider the results from the sequential logit equation. In the interests of brevity, we will concentrate on the effects that have different impacts on the probabilities of dropping in the first semester versus the second semester. These effects can be obtained from the last two rows of Table 7. For example, our 18-year-old, female, first-year student with the sample mean grade 13 average who took calculus and economics in high school would have had a 17-percentage point lower probability of dropping ECO 100 in the first semester and a 6-percentage point lower probability of dropping in the second semester than a similar student who did not take calculus and economics in high school. These effects are calculated by comparing column 4 with column 1. As a second example, a student with the above characteristics who did not take calculus and economics and had a grade 13 average of 90 percent would have a 3-percentage point (not statistically significant) *higher* probability of dropping the course in the first semester, but a 27-percentage point *lower* probability of dropping the course in the second semester than a student with a grade 13 average of 70 percent who also did not take calculus and economics in high school.

In summary, prior background in economics and calculus reduced the probability that a student would drop ECO 100 during the first semester. Past achievement, as represented by the grade 13 average grade, was the most important predictor of a student not dropping the course during the second semester when the cost of a drop decision is the highest.

THE GENDER EFFECT

The most puzzling aspect of all our regressions was the gender effect. Males were less likely to drop ECO 100 and tended to do better on average than their female colleagues. Do these findings reflect an inherently superior grasp of economic concepts? They do not reflect the different mathematical backgrounds of the students, because we included controls for these backgrounds. Nor do they reflect different average qualities, because we controlled for the grade 13 average grade and the performance on specific courses.[16] We do not know the answer to this question, but we have examined several alternative hypotheses.

As discussed earlier, high school students generally choose their own courses, and their choices will be correlated with their tastes and abilities. The different choices made by men and women in selecting their courses in the final year of high school are shown in Table 8. Again, the regressions fully accounted for the course selection of the individual student. What we hoped to gain by examining these choices and performances was an indication of any patterns suggesting the existence of an omitted variable that is correlated with course selection. Men and women in our sample had virtually identical mean grade 13 average grades (Table 8). Evidence does not appear to exist of any gap in overall ability between the two

TABLE 8
Attributes of Male and Female High School Records

	All students			St. George '88W		
	Male	Female	Test[a]	Male	Female	Test
Report algebra	48.6	32.5	11.79	50.5	33.6	7.53
Report calculus	80.5	76.4	3.51	80.1	74.3	3.01
Report economics	35.6	41.8	−4.57	36.7	42.9	−2.78
Report English	77.7	81.5	−3.41	79.1	84.0	−2.76
Report functions	68.5	65.5	2.31	67.3	62.6	2.15
Grade 13 average	79.2	79.5	−1.41	81.2	80.9	0.81
Std. dev. G13	7.45	6.93	1.16	6.66	6.19	1.16
Algebra grade	79.9	80.3	−0.78	79.6	80.4	−1.04
Calculus grade	78.5	77.6	2.27	77.9	77.2	1.32
Economics grade	79.6	79.6	0.11	79.4	79.2	0.32
English grade	73.8	75.7	−6.17	73.4	75.6	−5.16
Functions grade	79.9	79.0	2.24	79.3	78.3	1.73
Sample size	2,767	2,308		979	906	

[a]Tests are t tests for equality of male and female means, except for the test for Std. Dev. G13, the test of equality of variances of male and female grade 13 averages, which is an *F* test. The critical value for the *F* test is 1.00.

groups. The men and women did, however, take different courses. All five of the high school courses we considered were taken in significantly different proportions by men and women. Men took more algebra, calculus, and functions—in other words, more mathematics.[17] Some evidence exists that men are more mathematically oriented than women are (Benbow and Stanley 1980, 1982, 1983). Perhaps the fact that economics is not mathematically oriented in high school explains why more women take economics at the high school level (conditional on taking it at the university level).

Men perform better in calculus and functions, whereas women do better in English. There is a suggestion that the hypothesized gender differences in verbal versus mathematical skills are borne out in these data. Although there does not appear to be a gender effect in high school economics, the analytic nature of economics becomes much more evident in the university.

As a first attempt to eliminate the gender effect, we included a variable to control for the gender of the instructor. Because our database did not contain information on the identity of the instructor, we were forced to take an indirect approach to this hypothesis. We interacted the male variable with the Erindale campus variable, because Erindale had more female instructors. The parameter estimates corresponding to this specification are contained in column 1 of Table 9. The results were in the opposite direction from what is required to reduce the male premium. Men at Erindale actually got more of a bonus than their St. George counterparts, although the difference was not statistically significant.

Our second attempt to eliminate the gender effect was tied to the observation that men are regarded as having more variance in their abilities than women (Benbow and Stanley 1980, 1983). Because university course work results in a systematic lopping off of the bottom tail of the distribution of students, more low-quality men are dropped than women, and more high-quality men are rewarded. The conditional mean quality of men increases as the weeding-out activity proceeds. Put differently, because we reward students in the upper tail, and because more men are in the tails, they tend to do better on average than women. Two steps were taken to analyze this hypothesis. First, we determined whether any evidence existed in our sample that men were more variable in ability than women. In Table 8, we compare the means and variances of male and female grade 13 average grades. In Figure 1, we compare the density functions for our subsample of students enrolled in the winter 1988 session on the St. George campus. It is apparent from Figure 1 that the tails of the male density function are fatter, especially the upper tail. Applying the nonparametric test of Anderson (1990) yields the inference that the male and female densities are different,[18] and that the difference is primarily due to different variances. The parametric tests in Table 8 yield the same inferences.

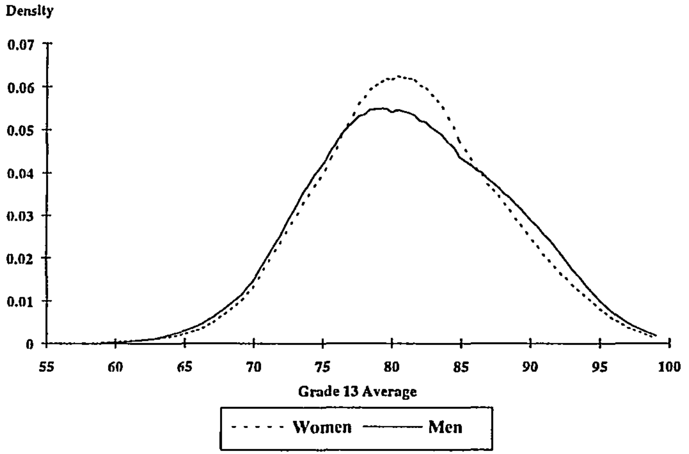
Figure 2 illustrates the effect of the weeding-out process. The male and female densities of ECO 100 grades were different,[19] but now the difference has been captured entirely by the difference in means, the variances being virtually identical (i.e., there is no-tails phenomenon).

TABLE 9
Determinants of Grade in ECO 100: Attempted Elimination of Gender Effect

	No grade 13 tail effect		With grade 13 tail effect	
Intercept	16.028	(14.556)	23.034	(14.705)
Male	3.276	(0.440)	3.263	(0.389)
Erindale	3.137	(0.724)	2.922	(0.522)
Gr 13 tail			2.126	(0.683)
Male at Erindale	0.097	(0.925)		
88 Summer session	2.766	(0.806)	2.795	(0.805)
88 Winter session	−2.609	(0.416)	−2.614	(0.416)
89 Summer session	−2.919	(0.782)	−2.933	(0.781)
Sophomore	1.328	(0.585)	1.384	(0.584)
Junior	2.164	(0.850)	2.132	(0.848)
Senior	3.097	(1.136)	3.117	(1.134)
Year 5	4.291	(1.616)	4.245	(1.614)
Year 6	6.784	(1.799)	6.656	(1.796)
Age	−3.254	(1.262)	−3.297	(1.260)
Age squared	0.064	(0.028)	0.065	(0.028)
Grade 13	0.998	(0.055)	0.911	(0.062)
Algebra indicator	−3.855	(2.479)	−2.611	(2.507)
Calculus indicator	−0.438	(2.033)	−0.256	(2.031)
Economics indicator	−10.899	(3.305)	−11.113	(3.300)
English indicator	4.902	(2.237)	5.084	(2.235)
Functions indicator	−1.931	(2.279)	−2.302	(2.279)
Algebra indicator	0.048	(0.032)	0.030	(0.032)
Calculus grade	0.053	(0.025)	0.052	(0.025)
Economics grade	0.143	(0.041)	0.146	(0.041)
English grade	−0.049	(0.029)	−0.052	(0.029)
Functions grade	0.021	(0.028)	0.026	(0.028)
R squared	0.32		0.32	

Notes: Dependent variable is grade in ECO 100. Sample size = 3,898. Standard errors are in parentheses. Gr 13 tail is a dummy variable equal to 1 if the student received greater than 86 percent in grade 13.

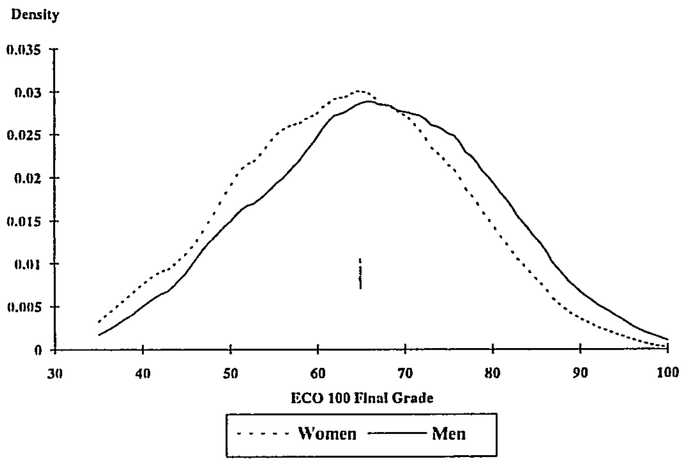
Figure 1
Density Estimates of Grade 13 Averages



To see whether the existence of a fatter upper tail in the male grade 13 density function could explain our male/female ECO 100 performance difference, we ran some additional regressions. In our previous regressions, we may not have controlled sufficiently for ability with just a measure of the grade 13 average. To capture the reward for being excellent, we included an additional control variable to indicate whether a student was in the upper tail of the grade 13 distribution. The results of this exercise were as follows. If a student was in the upper tail, there *was* an increase in her expected grade in ECO 100, conditional on her grade 13 average. However, no matter how the tail was defined, there was virtually no effect on the male premium. Column 2 of Table 9 contains the parameter estimates that resulted from adding a tail variable to the specification of Table 3, column 1, for the case that provided the maximum effect on the male premium. In this case, the tail variable took on the value unity if the grade 13 average was greater than 86 percent, and zero otherwise. The coefficient, which was significant, suggested a bonus of 2 percentage points for being in the tail, in addition to the effect of the grade 13 average.[20]

There is a third possible reason for the gender effect. As noted previously, it is possible that the unobserved variable effort is an important predictor of success in ECO 100. The percentage of ECO 100 students who were female was much higher than the percentage that major in programs requiring at least several additional economics courses.[21] This large difference is unlikely to be accounted for by the possible ex post discouraging effect of relatively poorer performance in ECO 100. If students rationally allocate their time to those subjects that are of

Figure 2
Density Estimates of ECO 100 Grades



more importance in future studies, women on average will devote less effort to ECO 100 than men will, and the unobserved effort effect will be correlated with the gender effect in a way that would produce a male premium.

We addressed this hypothesis in the following way. A popular joint major program in business and economics at the University of Toronto is the Commerce and Finance Program. This program requires 12 semester courses in economics in addition to ECO 100. A student signals a desire to enroll in the program (usually in the sophomore year) by taking ECO 100, Commerce 120H, and Mathematics 133 in the first year. We constructed a sample of 574 students who had successfully completed all three courses during the 1988 winter session. For such students, we would not expect effort to vary systematically by gender. Any gender effect that was found in this sample would be due to other reasons.

The grades in ECO 100, Commerce 120H, and Mathematics 133 were each regressed on the student characteristics listed in column 1 of Table 3. For ECO 100, the coefficient on the dummy variable male was 2.03 with a *t* statistic of 2.13. For the larger sample of all students who completed ECO 100 during the 1988 winter session (1,709 students), the corresponding coefficient was 2.65 with a *t* statistic of 3.92. The value and significance of the gender effect was reduced in the commerce and finance sample, but it remained statistically significant and meaningful. Hence it was unlikely that we could attribute the gender effect to unobserved gender-specific effort.

The significant gender effect in ECO 100 was in sharp contrast to the results for Commerce 120H and Mathematics 133. For the commerce and finance sample, the male coefficient for commerce was 0.86 ($t = 0.85$) and for mathematics 0.33 ($t = 0.34$). For the larger sample of students who completed at least Commerce 120H and ECO 100 (1,238 students), the male coefficient was 0.36 ($t = 0.39$). For those students completing at least Mathematics 133 and ECO 100 (894 students), the male coefficient was 0.73 ($t = 0.86$). There was no evidence of a statistically significant gender effect for economics students completing first-year business and mathematics courses; this finding only serves to deepen the mystery surrounding this well-documented effect in introductory economics.[22]

With respect to other effects of interest, the regression results for commerce and mathematics confirm the importance of the grade 13 average grade as a predictor of success.[23] In both cases it was the most significant variable, with a coefficient close to 1, paralleling the results for ECO 100. For commerce, the most important high school background preparation was a course in calculus, whereas for mathematics it was a course in algebra.[24]

CONCLUSIONS

In this article, we have analyzed the factors that determine a student's success in introductory economics, concentrating on information with respect to prior achievement and background. The most important factors were the overall achievement level (grade 13 average) and the taking of a course in calculus as a high school senior. Prior study of economics played a more complicated role in the determination of the final grade in ECO 100, having a positive influence only if the student had been relatively successful in the high school course. Background knowledge of calculus and economics were the most important determinants of the probability of dropping the course in the first semester, whereas the grade 13 average grade was the most important determinant of the decision to drop the course in the second semester.

Our estimate of the role of gender in influencing success in introductory economics is consistent with other studies. We estimate that men obtain 2.5 to 3.5-percentage points higher grades, on average, ceteris paribus. This consistency is no less disquieting for its existence. Several attempts to account for the male premium proved unsuccessful. Most disturbing was the persistence of this effect in a sample of students planning to major in economics, combined with the lack of a gender effect in business and mathematics courses taken by these same students. Clearly the persistence of the gender effect is a topic in need of further research.

Finally, another avenue of interesting future research in this era of reduced financial resources in higher education institutions is to explore the efficacy of using the structure estimated in this study to design an admissions rule for introductory economics. The goal of such a rule would be to permit any enrollment target that limits enrollment below the unconstrained demand to be met, but in such a way that the loss of those students most likely to succeed is minimized.

NOTES

1. It is for this reason that introductory economics at the University of Toronto is known without affection as the killing fields of the first year.

2. Only the fact that lecture class sizes are very large prevents a similar lopsided allocation of faculty resources. On the other hand, large class size does nothing to enhance the student experience.
3. For a contrary result, see Beron (1990). Becker, Greene, and Rosen (1990) also demonstrated that Heath's (1990) large effects arose from inappropriate substitution of TEL scores.
4. Our vintage results are consistent with those obtained by Bonello, Swartz, and Davisson (1984). Our results with respect to age appear to be new to this literature.
5. Students are assigned to sections by a random selection of ballots, each of which contains a student's ordering his or her top three preferences. The final examination, written in common by all students, is an end-of-the-year examination consisting of multiple-choice and short-answer questions that emphasize analytical ability. Section-specific term work consists of a series of term tests in the same format. The term work and the final examination are equally weighted in determining the final grade. Although the mean grades in the different sections are not equalized in any formal sense, the instructors meet to discuss significant discrepancies and tend to make adjustments that reduce the differences.
6. The grade 13 average is not the final average but rather the average submitted for college admission purposes, usually the average as of the middle of the senior year of high school. The subject-specific grades are final grades. Ontario high school seniors usually take seven or eight grade 13 subjects.
7. Ceteris paribus, grades on the suburban Erindale campus were higher by 3 percentage points. Although average grades varied significantly across sessions, no obvious pattern emerged. For example, average grades were not necessarily higher in summer sessions, as is often alleged.
8. Students need only report their highest six grades for admission purposes. For all subjects other than English, a value of zero for the variable indicates either the subject was not taken or was not among the top six grades obtained. Because English must be taken for university admission, a zero value for this indicator variable implies that the grade in English was not among the six highest. We use the phrase *not taken* when referring to a zero value for subjects other than English, but the more accurate designation should be kept in mind.
9. The beneficial impact of prior study and achievement in mathematics has been noted previously (Reid 1983; Myatt and Waddell 1990). However, the primacy of calculus, in comparison with other mathematics courses, appears to be a new result.
10. There is considerable interest in the economic education literature concerning the impact of high school economics on performance in college economics. Our results provide a more detailed description of the impact than is usually available. Note that when only indicator variables were included in the specification (column 2, Table 4), high school economics appeared to have an insignificant effect on the ECO 100 grade. This latter result is found in most studies (e.g., Harbury and Szreter 1968; Lumsden and Scott 1987). For a contrary conclusion, see Myatt and Waddell (1990).
11. We also considered the sensitivity of the results to excluding the insignificant effects of algebra and functions and relations and the English grade. The *F*-test statistic for the exclusion of the corresponding coefficients was 1.5. The critical 5 percent value is 2.2. The results do not change appreciably. If English is one of a student's top six grades, the ECO 100 grade is expected to be 1 percentage point higher. The calculus threshold grade is 24 percent, also well below any grade in the sample. The economics threshold grade now becomes 75 percent. The male premium remains at 3.3 percentage points.
12. That this issue may be of some importance can be seen from the following facts. We have observed that in our data the calculus grade had a positive effect and the English grade a negative effect on ECO 100 performance. Although there was a positive correlation between performance in calculus and English (top students got higher grades in most subjects), conditional on the grade 13 average, the correlation was negative. A higher percentage of men took calculus, and this tradeoff between achievement in English and calculus was more pronounced for men than for women.
13. Without an exclusion restriction, the usual λ correction is identified only by the nonlinearity of the inverse mills ratio. It is difficult to imagine an observable variable that affects whether students drop a course, but not their performance in that course. Because economics is compulsory for a number of majors, knowledge of the student's expected major might provide such a variable (conditional on the other variables in the grades equation).
14. The sequential model estimated is one in which during the first semester the student chooses between continuing and dropping, and then conditional on continuance, in the second semester chooses between dropping and completing the course.
15. All comparisons in this section of the article are between two students with these basic characteristics.

16. We are assuming that high school achievement differences adequately represent unobserved quality differences among students.
17. Note that all our inferences were drawn on students who took ECO 100 and may not be representative of the larger group of grade 13 students.
18. The chi-square test statistic with 2 degrees of freedom for differences in means and variances was 54.9. As noted by one of the referees, this evidence is not conclusive because men take more mathematics courses, and the grades tend to be more variable in those courses. If the larger male variance is due to course selection rather than more varied ability, then the effect of the upper tails variable introduced below will have a different interpretation than that given in the text. Under this alternative interpretation, the positive effect found will be indicative of a nonlinear relationship between achievement in mathematics and performance in ECO 100, rather than the linear relationship postulated in the basic model. However, the possibility that this alternative interpretation is the correct one does not alter the conclusion that the male premium persisted when this variable was added to the specification.
19. Anderson's test yielded a chi-square test statistic with 2 degrees of freedom for mean and variance differences of 26.4.
20. The grade 13 average coefficient declined from 1.0 (Table 3) to 0.9, complicating the comparison. It can be shown that the critical crossover grade was 90 percent. Below that grade, the grade 13 average had a greater impact on the ECO 100 grade under the specification without a tail variable, and above 90 percent the opposite was true.
21. For example, of the students enrolled in the winter 1988 session of ECO 100 on the St. George campus, 48 percent were women (Table 2). In the following year (winter 1989), of those students enrolled in the three second-year courses that are compulsory for economics majors, 41 percent were women. Of those students enrolled in the three second-year courses compulsory for economics specialists (Toronto's counterpart of an honors economics program), only 31 percent were women.
22. Another possible reason for the gender effect suggested by one of the referees is the form of evaluation used (short-answer and multiple-choice questions). Lumsden and Scott (1987) showed that men perform better than women on multiple-choice examinations, whereas the reverse is true in essay examinations. This effect may be present in our results, but we would be surprised if it was the complete answer. Unlike Lumsden and Scott, we had grades in English and mathematics among our explanatory variables, which should, at least to some extent, have provided controls for any differential abilities in verbal and quantitative skills. Evidence that our controls probably were effective is given by the fact that we observed no gender effect in the mathematics results, where differential verbal/quantitative abilities should be more important.
23. Because of space limitations, the complete set of regression results for commerce and mathematics are not presented. They are available from the authors upon request.
24. This statement for mathematics is not quite accurate. All students who enroll in Mathematics 133 have taken either high school calculus or a prior university calculus course, so the calculus dummy variable could be expected to have little discriminatory power. This expectation was confirmed by the results. For example, for the 894 student sample, the coefficient on the calculus dummy was -0.16 ($t = -.12$). A prior course in algebra is not a prerequisite for enrolling in Mathematics 133, so the algebra dummy variable is likely to have more discriminatory power. This expectation was confirmed by the results, which indicated that those with grade 13 algebra had an expected grade in Mathematics 133 that was 4 to 5 points higher than those without the course (coefficient $= 4.64$, $t = 5.15$).

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