Gender-Based Retention in Principles of Microeconomics at the University of Colorado Boulder

By: Amy Burnett
Advised by: Dr. Jeffrey Zax, Economics
Committee member: Dr. Nicholas Flores, Economics
Committee member: Dr. Celeste Montoya, Women and Gender Studies

University of Colorado at Boulder
Department of Economics

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Abstract

This study employs a linear probability model to explore differences between male and female students taking Principles of Microeconomics courses during their first year of study at the University of Colorado at Boulder. Data is analyzed with stratification according to major choice (whether or not the student has declared economics as a major) at three time periods (upon admission, fall semester, and spring semester) to determine if there is a meaningful difference between male and female students. This study demonstrates that the holes in the "leaky pipeline" are actually relatively small when it comes to women's experiences in Principles of Economics in their first year of school. The only regression with a statistically significant β for gender is the one that does not control for student experiences in the first year of college and measures major declared upon admission.

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1 Introduction

The Committee on the Status of Women in the Economics Profession (CSWEP[1]) reports that in 2011 only 35.6% of students graduating with Economics degrees at liberal arts colleges were women. Females only accounted for 24.4% of full professors in Economics (Fraumeni 3). This evidence suggests that Economics has issues with the "leaky pipeline" observed for women in engineering, science, and many other male dominated fields.

Gendered attrition in undergraduate economics is not a new issue. Claudia Goldin of Harvard offers the following descriptions of this issue:

> Women have been a growing fraction of all BAs in the United States since the 1950s and became half of the group around 1980. In 2011, women were 57 percent of all BAs at institutions that offered degrees in economics, 52 percent of all BAs at the top 100 universities and 56 percent of all BAs at the top 100 liberal arts colleges. Yet economics has not increased its share of the group in the 20 years... For all but the top private universities, economics has had a decreased fraction of female BAs. (Goldin 4)

This "leaky pipeline" represents all of the relevant points at which women's experiences differ from men's on a career trajectory. From high school math classrooms to the American boardroom, significant differences in advancement outcomes exist between men and women. This study focuses on one discrete point in this leaky pipeline: the Principles of Microeconomics course taught to freshmen at the University of Colorado Boulder. While Principles of Microeconomics comprise only one piece of the puzzle of gender-based attrition in economics, it is a pivotal point in which women are lost to the field for good.

The Association for the Study of Higher Education finds that "students' scores on standardized tests of critical thinking grow when they encounter diversity... when

[1]The Committee on the Status of Women in the Economics Profession is a standing committee of the American Economic Association charged with serving professional women economists in academia, government agencies and elsewhere by promoting their careers and monitoring their progress.

they come into contact with students from backgrounds that are different from their own" (Berrett). This effect continues throughout the entire pipeline as companies that achieve higher rates of women's representation on boards attain better financial results, on average, than other companies (Carter and Wagner).

This indicates that male students could benefit from increased female presence and participation in the economics classroom. Gender equity in Economics departments also affects the leadership of top companies in America. One study found that 9% of Standard & Poor's 500 company's CEOs have undergraduate degrees in Economics. Their findings suggest that increasing female enrollment in undergraduate Economics program would help increase the number of female CEOs of S&P companies who currently account for only 2% of the demographic (Flynn and Quinn 58).

Furthermore, gender equity in economics departments affects future wages of students. Another study looks at this question carefully by demonstrating that the only major with higher average wages than economics is engineering. Consequently, the lack of gender equity for undergraduate enrollment in economics affects larger questions of social gender equity (Black, Sanders, and Taylor).

My thesis will explore the crux of the Principles of Microeconomics course for women at the University of Colorado at Boulder. The questions I seek to answer with my thesis is "Among students who take Principles of Microeconomics at CU, are women less likely to major in Economics, even after controlling for student characteristics and performance? And, if they are, can we tell anything about why?".

2 Literature Review

Previous studies that address gender and economics enrollment have approached the question from different angles. Some look at university-wide data and major choice. Others look at surveys of students in principles of microeconomics courses. Still others use statistics collected by universities on both admissions and temporal data on women's choices in their first year of college.

Not surprisingly, economics educators have been looking at issues of gender equity using econometrics since the early 1980s. Testing of the claim that men are inherently better at economics, as measured by performance in principles courses, has occurred over decades. A meta-regression of 325 relevant regressions indicated that in 68.4% of the regressions, men outperform otherwise equivalent women. Yet only 30.7% of these studies have statistically significant regressions, "calling into question the conventional wisdom that men are better at economics than women" (Johnson, Robson, and Taengnoi 455).

Other studies approach this question by looking at the factors that affect the graduation rate of women in undergraduate economics programs. By creating variables that measure the friendliness toward female students and faculty, another study discover that the role model effect is significant, and the "friendliness toward females" variable is highly significant: indicating a spillover effect within an institution that values women's issues (Taengnoi and Burnett 9). This study also demonstrates that universities with Women's Studies departments have higher graduation rates of women in economics. This study implies that the overall characteristics of the university are highly correlated with female undergraduate economics major success. In other words the presence of programs on campus that value women have a positive correlation to female graduation rates in economics.

One critical junction in choices made by women studying economics is during the first year of university-level study of economics, when students are choosing a major. Researchers followed three broad research methodologies in order to understand why female attrition in economics is so high after Principles of Microeconomics courses. Survey of principles students, university admissions data for students in principles courses, and university data on enrollment choices have all been used to understand why gender-based attrition exists in economics courses.

Surveys have offered useful data to answer questions on gender-based attrition in economics. One study directly asks students which factors are most important to enrollment choices. They find that female respondents are much less likely to ever

consider economics as a major. Many women who do take Principles of Microeconomics do so only to fulfill a liberal arts requirement. Female students were also more likely to respond that the material was too hard and too mathematical (Calkins and Welki 558).

Another study determined that students' confidence in their ability to understand economics, their perception that economics is relevant, their predisposition to major in economics, and their perception that economics is important to their career are all positive determinants in students' decisions to continue studying economics past principles courses (Jensen and A. L. Owen, "Why Are Women Such Reluctant Economists? Evidence from Liberal Arts Colleges"). A similar survey-based study discovered that prior experiences in economics negatively impact a woman's performance much more strongly than men. Furthermore women's attitudes on their own poor performance negatively influence the gender gap in economics courses (Ballard and Johnson 95). This suggests that in addition to structural modifications within courses, additional support for women outside the classroom could impact future enrollment.

Another study used survey results to demonstrate that teaching techniques and evaluation methods influence women students' attitudes regarding the relevance of economics, their belief that they understand economics as well as their classmates, and their expectation of receiving a grade that is better than most of their classmates (Jensen and A. L. Owen, "Pedagogy, Gender, and Interest in Economics"). Another survey based study of students in Harvard's principles economics courses in 1997 to find that perceived aptitude in the course relative to other courses matters much more than absolute measures of student success, such as grades (Dynana and Rouse 365).

A recent study looked at university admissions data for all students entering economics studies in the UK (Tonin and Wahba 3). They found that females have less math prior to entry but this does not entirely explain the gender gap in economics programs.

Another study uses a multi-institution 11 year dataset to find trends in enrollment for women at schools with both economics and engineering programs (Emerson, Mc-

Goldrick, and Mumford 349). This study finds that the female students who take principles economics courses with higher math scores and those who are stronger in math are likely opting into engineering and other quantitative disciplines more than otherwise similar men.

Another way of looking at enrolled student data is by analyzing the patterns of students who drop principles economics courses. Another study on this topic indicates that students who do not drop principles of economics tend to be doing well in school and are also enrolled in calculus during the course of their principles study (Bosshardt 111). While this study is not directly related to gender I included it because of the high correlation between math experience and economics as a major. While this certainly does affect the outcome of whether women declare economics as a major, the intervention strategy lies outside the scope of the economics department, barring some remedial math course available to women studying economics only. Other studies have clearly indicated a gender gap in math performance that could affect ability to succeed in an economics program. While this study did indicate that students appeared to be efficient in the dropping pattern, he did not link this to gendered outcomes (111). However, we can be sure that if math is important to succeeding in Principles of Microeconomics, we will see fewer women succeed in these classes. This is due to the fact that women are likely to come to college with less math background. This paper will demonstrate that math background is essential to understanding the concepts in Principles of Microeconomics. Rather than taking this as a de facto reason that women are inherently less capable as economists, we can use this to bolster claims that primary and secondary math programs are the root source of the gender imbalances we see in Principles of Microeconomics.

The final component of undergraduate student enrollment that is extensively studied is the effect of grade sensitivity on gender imbalance in the economics classroom. The Principles of Microeconomics program "from a liberal arts college where economics is a popular major" studied over a period of 16 years, women are significantly more responsive to the relative grade received than men (Rask and Tiefenthaler 676). There-

fore "weed out" courses have a disproportionately strong effect on women. Another study confirms this result with a regression discontinuity analysis that demonstrates that even while controlling for GPA, receiving an A for a final grade in the first university level economics class is associated with a meaningful increase in the probability of majoring in economics for both genders, but disproportionately more so for women (A. Owen 217).

Gender equity in the economics classroom is a pivotal issue and important to understand and solve. The gender gap within the field creates a real and meaningful challenge for economics education administrators and educators because the divide is seen as early as undergraduate economics education. The University of Colorado has gender attrition statistics that follow the national norms. Therefore I will evaluate CU institutional data to test these trends.

3 Data

The data for this study came from various institutions on campus. The Office of Planning, Budget and Analysis at the University of Colorado at Boulder provided all the information on student admission data, as well as performance and major choice during the first year at CU. FCQs were collected from CU's online repository[2]. Professor gender was collected from CU Boulder's economics department website where available. Other departmental records were used where this was unavailable. I merged all of these data sources into one dataset that contained one row per student in the sample.

[2]Faculty Course Questionnaires can be downloaded from the Office of Planning, Budget and Analysis at https://fcq.colorado.edu/UCBdata.htm.

Table 1: Descriptive Statistics - all students

	N	min	max	median	mean	sd
Female	3683	0.00	1.00	0.00	0.35	0.48
Non-resident alien	3683	0.00	1.00	0.00	0.01	0.10
Hispanic	3683	0.00	1.00	0.00	0.09	0.29
American Indian	3683	0.00	1.00	0.00	0.02	0.13
Asian	3683	0.00	1.00	0.00	0.08	0.27
Black	3683	0.00	1.00	0.00	0.02	0.15
White	3683	0.00	1.00	1.00	0.89	0.31
Pacific Islander	3683	0.00	1.00	0.00	0.01	0.08
High school GPA	3683	2.20	4.00	3.53	3.52	0.36
Admission index	3683	80.00	146.00	116.00	116.16	10.13
Admit major: Econ	3683	0.00	1.00	0.00	0.04	0.19
Fall major: Econ	3683	0.00	1.00	0.00	0.05	0.22
Spring major: Econ	3683	0.00	1.00	0.00	0.06	0.24
Admit major: Pol Sci	3683	0.00	1.00	0.00	0.02	0.15
Fall major: Pol Sci	3683	0.00	1.00	0.00	0.02	0.14
Admit major: Env Studies	3683	0.00	1.00	0.00	0.03	0.17
Fall major: Env Studies	3683	0.00	1.00	0.00	0.03	0.17
Admit major: Int'l Affairs	3683	0.00	1.00	0.00	0.02	0.13
Fall major: Int'l Affairs	3683	0.00	1.00	0.00	0.02	0.15
Admit major: Journalism	3683	0.00	0.00	0.00	0.00	0.00
Fall major: Journalism	3683	0.00	0.00	0.00	0.00	0.00
Admit major: B-School	3683	0.00	1.00	0.00	0.42	0.49
Fall major: B-School	3683	0.00	1.00	0.00	0.40	0.49
Test Performance Total (SAT scale)	3683	640.00	1600.00	1170.00	1172.25	120.67
Test Performance Math (SAT scale)	3683	340.00	800.00	600.00	598.87	68.79
Lower Math	3683	0.00	1.00	1.00	0.65	0.48
Upper Math	3683	0.00	1.00	0.00	0.03	0.17
Grade received in Microeconomics	3683	0.00	4.00	2.70	2.64	0.95
Best grade	3683	0.00	4.00	3.70	3.52	0.69
FCQ: Course Overall	3683	3.10	5.10	4.20	4.12	0.57
FCQ: Instructor Overall	3683	3.00	5.50	4.50	4.39	0.72
FCQ: Prior Interest	3683	2.50	4.50	3.30	3.39	0.31
Female professor	3683	0.00	1.00	0.00	0.16	0.37
Cohort Year 2011	3683	0.00	1.00	0.00	0.37	0.48
Cohort Year 2012	3683	0.00	1.00	0.00	0.35	0.48
Cohort Year 2013	3683	0.00	1.00	0.00	0.28	0.45

Table 2: Descriptive Statistics - women

	N	min	max	median	mean	sd
Female	1275	1.00	1.00	1.00	1.00	0.00
Non-resident alien	1275	0.00	1.00	0.00	0.01	0.09
Hispanic	1275	0.00	1.00	0.00	0.11	0.31
American Indian	1275	0.00	1.00	0.00	0.01	0.11
Asian	1275	0.00	1.00	0.00	0.09	0.29
Black	1275	0.00	1.00	0.00	0.02	0.15
White	1275	0.00	1.00	1.00	0.88	0.33
Pacific Islander	1275	0.00	1.00	0.00	0.01	0.10
High school GPA	1275	2.20	4.00	3.70	3.66	0.33
Admission index	1275	81.00	144.00	119.00	118.21	9.84
Admit major: Econ	1275	0.00	1.00	0.00	0.02	0.13
Admit major: Econ	1275	0.00	1.00	0.00	0.03	0.17
Spring major: Econ	1275	0.00	1.00	0.00	0.04	0.19
Admit major: Pol Sci	1275	0.00	1.00	0.00	0.02	0.14
Fall major: Pol Sci	1275	0.00	1.00	0.00	0.02	0.14
Admit major: Env Studies	1275	0.00	1.00	0.00	0.03	0.17
Fall major: Env Studies	1275	0.00	1.00	0.00	0.03	0.18
Admit major: Int'l Affairs	1275	0.00	1.00	0.00	0.03	0.16
Fall major: Int'l Affairs	1275	0.00	1.00	0.00	0.03	0.18
Admit major: Journalism	1275	0.00	0.00	0.00	0.00	0.00
Fall major: Journalism	1275	0.00	0.00	0.00	0.00	0.00
Admit major: B-School	1275	0.00	1.00	0.00	0.48	0.50
Fall major: B-School	1275	0.00	1.00	0.00	0.45	0.50
Test Performance Total (SAT scale)	1275	640.00	1570.00	1150.00	1164.52	120.59
Test Performance Math (SAT scale)	1275	340.00	800.00	580.00	586.70	67.47
Lower Math	1275	0.00	1.00	1.00	0.62	0.49
Upper Math	1275	0.00	1.00	0.00	0.02	0.14
Grade received in Microeconomics	1275	0.00	4.00	2.70	2.67	0.95
Best grade	1275	0.00	4.00	4.00	3.68	0.57
FCQ: Course Overall	1275	3.10	5.10	4.20	4.12	0.55
FCQ: Instructor Overall	1275	3.00	5.50	4.50	4.39	0.71
FCQ: Prior Interest	1275	2.50	4.50	3.30	3.37	0.30
Female professor	1275	0.00	1.00	0.00	0.15	0.36
Cohort Year 2011	1275	0.00	1.00	0.00	0.36	0.48
Cohort Year 2012	1275	0.00	1.00	0.00	0.36	0.48
Cohort Year 2013	1275	0.00	1.00	0.00	0.28	0.45

Table 3: Descriptive Statistics - men

	N	min	max	median	mean	sd
Female	2408	0.00	0.00	0.00	0.00	0.00
Non-resident alien	2408	0.00	1.00	0.00	0.01	0.11
Hispanic	2408	0.00	1.00	0.00	0.09	0.28
American Indian	2408	0.00	1.00	0.00	0.02	0.14
Asian	2408	0.00	1.00	0.00	0.08	0.26
Black	2408	0.00	1.00	0.00	0.02	0.15
White	2408	0.00	1.00	1.00	0.90	0.30
Pacific Islander	2408	0.00	1.00	0.00	0.01	0.08
High school GPA	2408	2.32	4.00	3.45	3.45	0.35
Admission index	2408	80.00	146.00	114.00	115.07	10.12
Admit major: Econ	2408	0.00	1.00	0.00	0.05	0.22
Admit major: Econ	2408	0.00	1.00	0.00	0.06	0.24
Spring major: Econ	2408	0.00	1.00	0.00	0.08	0.27
Admit major: Pol Sci	2408	0.00	1.00	0.00	0.02	0.15
Fall major: Pol Sci	2408	0.00	1.00	0.00	0.02	0.14
Admit major: Env Studies	2408	0.00	1.00	0.00	0.03	0.16
Fall major: Env Studies	2408	0.00	1.00	0.00	0.03	0.17
Admit major: Int'l Affairs	2408	0.00	1.00	0.00	0.01	0.11
Fall major: Int'l Affairs	2408	0.00	1.00	0.00	0.02	0.12
Admit major: Journalism	2408	0.00	0.00	0.00	0.00	0.00
Fall major: Journalism	2408	0.00	0.00	0.00	0.00	0.00
Admit major: B-School	2408	0.00	1.00	0.00	0.38	0.49
Fall major: B-School	2408	0.00	1.00	0.00	0.37	0.48
Test Performance Total (SAT scale)	2408	790.00	1600.00	1190.00	1176.35	120.54
Test Performance Math (SAT scale)	2408	390.00	800.00	600.00	605.32	68.62
Lower Math	2408	0.00	1.00	1.00	0.67	0.47
Upper Math	2408	0.00	1.00	0.00	0.04	0.19
Grade received in Microeconomics	2408	0.00	4.00	2.70	2.63	0.95
Best grade	2408	0.00	4.00	3.70	3.44	0.74
FCQ: Course Overall	2408	3.10	5.10	4.20	4.12	0.58
FCQ: Instructor Overall	2408	3.00	5.50	4.50	4.39	0.73
FCQ: Prior Interest	2408	2.50	4.50	3.30	3.39	0.31
Female professor	2408	0.00	1.00	0.00	0.16	0.37
Cohort Year 2011	2408	0.00	1.00	0.00	0.37	0.48
Cohort Year 2012	2408	0.00	1.00	0.00	0.35	0.48
Cohort Year 2013	2408	0.00	1.00	0.00	0.28	0.45

Most variables required further evaluation before use in regressions. Most of the independent variables are indicator (dummy) variables that required very little interpretation from the raw data. The dependent variables (economics major at admissions, economics major in fall, economics major in spring) were generated from string variables given for each student indicating their primary major choice for each time period. A value of 1 was assigned to each student who had chosen economics during that time period. All other students were assigned a values of 0 for economics.

I also tracked all instances where a student declared a major that required Principles of Economics which included Political Science, Environmental Studies, International Studies, and all majors in the business school. The dummy variables for Political Science, Environmental Studies, and International Studies majors indicate that a student has declared that major with a value of 1. The business school major variable indicates that the student has declared a business major (accounting, finance, management and entrepreneurship, and marketing) with a value of 1. If student does not have a particular major marked they receive a value of 0 for that category.

CU Boulder does allow students to declare multiple majors, and that information has been captured by this study, as well. This study treats a primary, secondary, or tertiary major (as listed in the original data) identically. If a student has declared a major at a relevant time period (for example, Political Science in fall), they will receive a value of 1 for the relevant variable representing that major. Therefore it is possible for multiple student's majors to be counted in this study by values of 1 in multiple dummy variables for major. Likewise, if a student declares a major that does not require Principles of Microeconomics, this student would receive a value of 0 for all dummy variables representing majors.

All race/ethnicity variables were generated from dummy variables representing six race/ethnicity codes categories as they are self reported at admit. I preserved the original language represented by the university in the construction of these variables. Students were allowed to choose multiple races/ethnicities. Therefore, the means of each indicator (dummy) variables in summation is greater than 1.

The variable Hispanic was generated from the dummy variable for students who self reported a Hispanic ethnicity on their university application. A value of 1 was assigned to each student who was coded as Hispanic. All other students were assigned a value of 0 for Hispanic. The other race/ethnicity variables (American Indian, Asian, Black, Pacific Islander, and White) were generated using the same method.

The non-resident variable indicates whether or not the student is a non-resident of the United States. A value of 1 was assigned to each student who was coded as "nonresident" in the original data. All other students were assigned a value of 0 for the non-resident variable.

The Index variable represents a standardized score used for admission purposes to Colorado public universities, The score is generated by the Colorado Department of Higher Education as a "quantitative evaluation that is part of a larger student application evaluation". Because the sample for this study is all freshmen, all index variables are based on "a combination of a student's high school GPA or high score rank percentage combined with ACT or SAT score[3]". Higher scores indicate a more attractive candidate due to higher academic and standardized test performance. The mandatory minimum for admission to CU Boulder is 103[4].

High school GPA is an unweighted variable with a maximum value of 4.0. It was also one of the biggest limitations of this study, as not every student had a reported high school GPA. 259 students did not have a high school GPA, and were omitted from the sample.

I generated "Test Performance" from the highest value reported from the SAT I total score and a converted ACT composite score, represented on an SAT scale[5]. Likewise, Test Performance Math is generated from the highest value reported from the SAT I math score and a converted ACT math score, represented on an SAT score.

[3]Criteria for the Colorado Department of Higher Education's "Index Score" are detailed at http://highered.colorado.gov/academics/admissions/IndexScore/default.asp.

[4]Minimum thresholds for public universities and colleges in Colorado can be found at http://highered.colorado.gov/publications/policies/current/i-partf-index.pdf.

[5]In order to calculate this conversion I used the ACT's official conversion thresholds which can be found at http://www.act.org/aap/concordance/estimate.html.

This was necessary because not all students reported SAT or ACT upon admission. This statistic was another critically weak point in the data. Thus, students who did not have SAT or ACT scores reported were dropped from the dataset. 128 students did not have any test scores reported, and were omitted from the sample.

"Lower math" is a complicated dummy variable. I assigned "lower math" a value of 1 if at least one of the following criteria is met for the student: student was enrolled in or had received credit for MATH 1150 or ECON 1088 while enrolled in Principles of Microeconomics, or student had a value of 1 for "upper math" . This indicates that the student has achieved, or is in the process of achieving, a fundamental amount of math necessary to understand the graphs and concepts in Microeconomics. These course numbers were generated from the requirements worksheet for a BA economics major at CU Boulder[6]. If none of these criteria are met, the student is assigned a value of 0, indicating that the student has not achieved a basic understanding of the math required to study economics. If this variable has a value of 1, then lower level math will also have a value of 1.

Similarly, "Upper math" indicates progress towards an understanding of calculus. I assigned students a value of 1 if the student met at least one of the following conditions: student received credit for AP Calculus AB or BC, or IB Higher Level Mathematics; student was enrolled in MATH 1300 while taking Microeconomics; or student had credit for MATH 1300 before Microeconomics. This variable indicates whether a student has achieved a basic understanding of Calculus. If none of these criteria are met, the student is assigned a value of 0, indicating that the student has not achieved a basic understanding of the math required to study economics.

The "grade received in Microeconomics" variable was converted from a string reporting the grade received in ECON 2010, according to the following scale:

[6]The requirements for economics students interested in pursuing a BA in economics from CU Boulder can be found at http://www.colorado.edu/economics/undergraduate/major.pdf.

Table 4: Grade Letter Conversion

	grade	assigned_value
1	A	4.00
2	A-	3.70
3	B+	3.30
4	B	3.00
5	B-	2.70
6	C+	2.30
7	C	2.00
8	C-	1.70
9	D+	1.30
10	D	1.00
11	D-	0.70
12	F	0.00

This variable was also used to screen out students who did not complete Microeconomics. If a student did not have a reported grade, they were dropped from the dataset. The following tables represents the distribution of this variable for males, females and all. In this sample, there is no meaningful difference between male and female students for grades in the Principles of Microeconomics course for freshmen. In fact, table 5 indicates that the grade distribution for males and females appears to be identical for Principles of Microeconomics.

Table 5: Microeconomics Grade

	mean	sd	25%	75%	90%
All students	2.64	0.95	2.00	3.30	4.00
Females	2.67	0.95	2.00	3.30	4.00
Males	2.63	0.95	2.00	3.30	4.00

Using the same scale, "best grade" was also calculated to capture the best non-economics grade in a course that could lead to another major. Grades earned in courses that could not lead to a major such as WRTG (from the Writing and Rhetoric Program), the Air Force Aerospace Studies program, and the Sewell Residential Program were not used in the calculation of "best grade". This variable is an attempt to capture how students are doing in courses that could be pulling them out of the economics pipeline. This approach is similar to the one taken by Dynan and Rouse in

which relative performance is a key variable. It represents a very important concept from the data. The following tables represent the distribution of this variable for males, females, and all students.

Additionally we are interested in relative performance in Principles of Microeconomics in comparison with "best grade," which demonstrates the propensity of another class to pull a student away from the study of economics. Table 7 shows the gender distribution of this variable, which indicates that female students perform relatively better in other classes than Principles of Microeconomics than their male counterparts.

Table 6: Best Grade

	mean	sd	25%	75%	90%
All students	3.52	0.69	3.30	4.00	4.00
Females	3.68	0.57	3.70	4.00	4.00
Males	3.44	0.74	3.00	4.00	4.00

Table 7: Best Grade - Microeconomics Grade

	mean	sd	25%	75%	90%
All students	0.88	0.81	0.30	1.30	2.00
Females	1.01	0.82	0.30	1.70	2.00
Males	0.81	0.80	0.30	1.30	1.70

FCQ data (course overall and prior interest) came directly from the FCQ summaries reported online. All students in the same section of the course were assigned the same values for these FCQ variables, regardless of gender.

Table 8: FCQ Statistics - all students

	N	min	max	median	mean	sd
gender	3683	0.00	1.00	0.00	0.35	0.48
FCQ: Course Overall	3683	3.10	5.10	4.20	4.12	0.57
FCQ: Instructor Overall	3683	3.00	5.50	4.50	4.39	0.72
FCQ: Prior Interest	3683	2.50	4.50	3.30	3.39	0.31

And finally, "Female professor" indicates the gender of the professor. It was largely designated by a "look and assign" methodology for the gender of each professor who taught Microeconomics in the sample. I consulted other departmental records when the website approach did not apply.

4 Methodology

This study employs a linear probability model to explore important margins of difference between male and female students taking principles of economics courses during their first year of study at the University of Colorado at Boulder. Two models are used to explore these differences: linear probability, and linear probability with interaction effects on the control variables. This is done in three time periods (upon admission, at the end of the fall semester, and at the end of the spring semester), according to the following figures.

Figure 1.

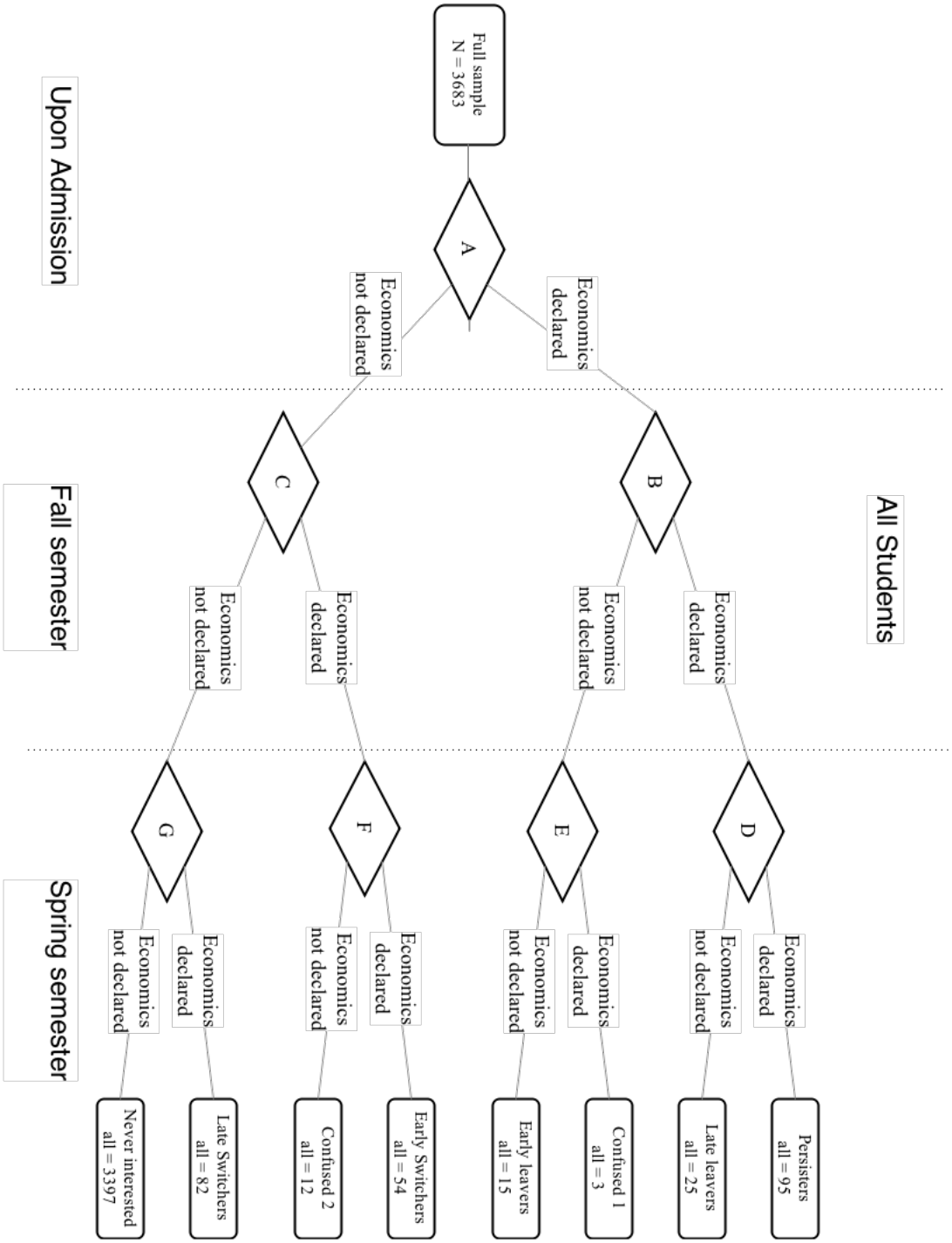

Upon Admission
Fall semester
Spring semester
All Students
Full sample
N = 3683
A
Economics
declared
Economics
not declared
B
C
Economics
declared
Economics
not declared
Economics
declared
Economics
not declared
D
E
F
G
Economics
declared
Economics
not declared
Economics
declared
Economics
not declared
Economics
declared
Economics
not declared
Persisters
all = 95
Late leavers
all = 25
Confused 1
all = 3
Early leavers
all = 15
Early Switchers
all = 54
Confused 2
all = 12
Late Switchers
all = 82
Never interested
all = 3397

Figure 2.

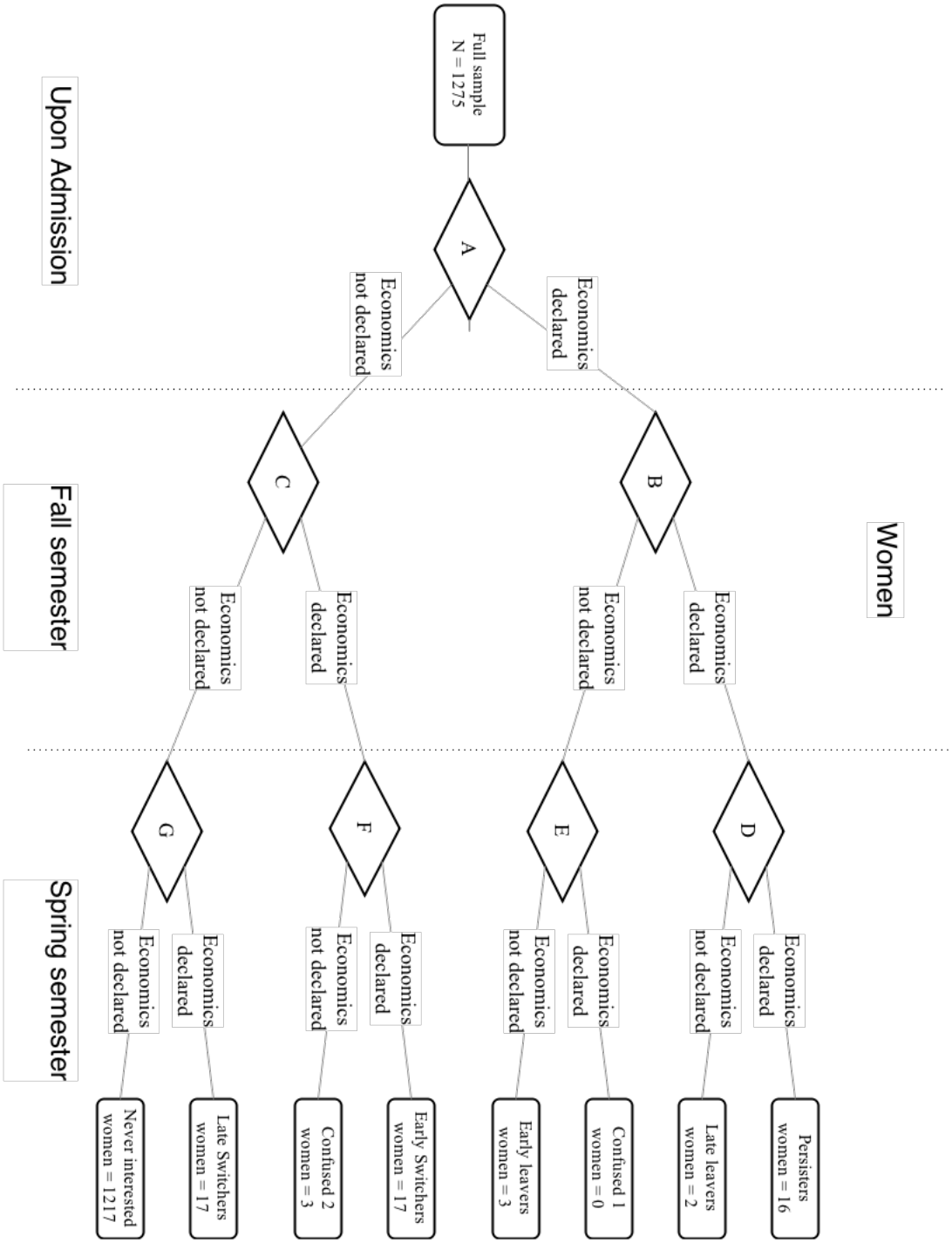
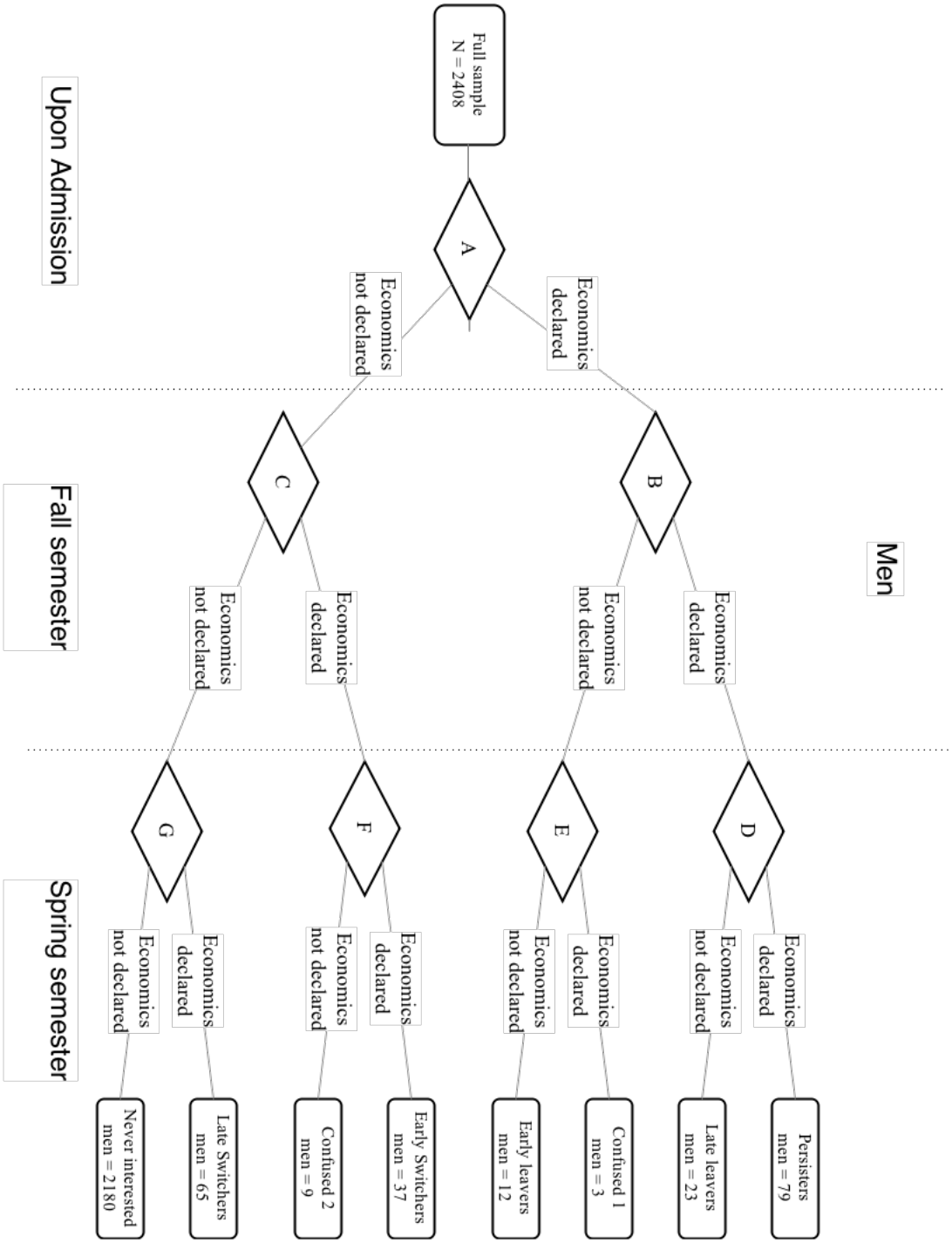

Women
Upon Admission
Fall semester
Spring semester
Full sample
N = 1275
A
Economics
declared
Economics
not declared
B
C
Economics
declared
Economics
not declared
Economics
declared
Economics
not declared
D
E
F
G
Economics
declared
Economics
not declared
Economics
declared
Economics
not declared
Economics
declared
Economics
not declared
Economics
declared
Economics
not declared
Persisters
women = 16
Late leavers
women = 2
Confused 1
women = 0
Early leavers
women = 3
Early Switchers
women = 17
Confused 2
women = 3
Late Switchers
women = 17
Never interested
women = 1217

Figure 3.


Men
Upon Admission
Fall semester
Spring semester
Full sample
N = 2408
A
Economics declared
Economics not declared
B
C
Economics declared
Economics not declared
Economics declared
Economics not declared
D
E
F
G
Economics declared
Economics not declared
Economics declared
Economics not declared
Economics declared
Economics not declared
Economics declared
Economics not declared
Persisters men = 79
Late leavers men = 23
Confused 1 men = 3
Early leavers not declared
Early Switchers men = 37
Confused 2 men = 9
Late Switchers men = 65
Never interested men = 2180

The sample is divided into three time periods: admission, fall, and spring. Each diamond on the graph represents a point when students can choose to declare economics or not. This choice is recorded once per semester. The first point is represented by diamond A, and will be analyzed in Regression Set A below. All students who declare economics upon admittance are included in Regression Set B. The remainder go into Regression Set C. Similar splits are made in the resulting groups. Therefore, each progressing set of groups get smaller as the sample is divided into further subcategories. We are left with eight final groups: persisters (students who declared economics at every time period), late leavers, confused 1, early leavers, early switchers, confused 2, late switchers, and never interested. Descriptive statistics are available in Figure 1 that give sample sizes for each sub-sample. Figure 2 presents the women sub-samples for each group. Figure 3 presents the men sub-samples for each group.

5 Model Selection

This study explored two different models to determine which explained the data better.

Model without interaction effects

$$\underbrace{(y_t)}_{\substack{\text{Economics major}\\ \text{at time t}}} = \alpha + \underbrace{\beta_F 1_{Fi}}_{\text{gender effect}} + \underbrace{\sum_{i=1}^{j}[\beta_j(x_{ij})]}_{\substack{\text{student characteristics'}\\ \text{effects}}} + \underbrace{\sum_{i=1}^{k}[\beta_j(x_{ik})]}_{\substack{\text{effects of Microeconomics}\\ \text{Course at CU}}} + \varepsilon_i \quad (1)$$

Model with interaction effects

$$\underbrace{(y_t)}_{\substack{\text{Economics major}\\ \text{at time t}}} = \alpha + \underbrace{\beta_F 1_{Fi}}_{\text{gender effect}} + \underbrace{\sum_{i=1}^{j}[\beta_j(x_{ij})]}_{\substack{\text{student characteristics'}\\ \text{effects}}} + \underbrace{\sum_{i=1}^{j}[\beta_{F\cdot i}[F_i \cdot (x_{1i})]]}_{\substack{\text{interaction effects of gender}\\ \text{with student characteristics}}} + \underbrace{\sum_{i=1}^{k}[\beta_j(x_{ik})]}_{\substack{\text{effects of Microeconomics}\\ \text{Course at CU}}} + \underbrace{\sum_{i=1}^{k}[\beta_{F\cdot i}[F_i \cdot (x_{1i})]]}_{\substack{\text{interaction effects of gender}\\ \text{with Microeconomics Course at CU}}} + \varepsilon_i \quad (2)$$

Two models are initially calculated: a constrained (no interaction – represented by the left column of numbers in each results table, below) regression and an unconstrained

(each control variable is interacted with gender– represented by the right column of numbers in each results table, below) regression. In order to determine whether the unconstrained regression offers a statistically significantly better explanation of the data than the constrained regression, we run a 2-regression F-test. We set the critical p-value at 0.05 for this F-test.

6 Results

Regression A

The first regression uses the entire sample of cohorts 2011, 2012, and 2013. All students in the sample took Principles of Microeconomics at CU in their freshmen year. The dependent variable represents whether or not the student declares economics as a major upon admission, and offers a baseline for later regressions.

Table 9: Regression Set A

	Dependent variable:	
	Economics declared at admit	
	(1)	(2)
Female	-0.020^{***}	0.007
	t = −2.871	t = 0.079
Non-resident alien	0.017	0.003
	t = 0.539	t = 0.082
Hispanic	0.013	0.025^{*}
	t = 1.151	t = 1.670
American Indian	−0.031	−0.036
	t = −1.323	t = −1.317
Asian	−0.016	−0.027
	t = −1.062	t = −1.373
Black	0.015	0.031
	t = 0.673	t = 1.085
Pacific Islander	0.005	0.023
	t = 0.142	t = 0.444
White	−0.014	−0.017
	t = −0.997	t = −0.937
High school GPA	−0.051	−0.069
	t = −1.274	t = −1.316
Admission index	−0.0003	0.00001
	t = −0.148	t = 0.005
Cohort Year 2012	0.005	0.007
	t = 0.726	t = 0.813
Cohort Year 2013	−0.001	−0.0002
	t = −0.114	t = −0.019
Test Performance Math (SAT scale)	−0.00001	−0.00004
	t = −0.119	t = −0.397
Test Performance Total (SAT scale)	0.0001	0.0001
	t = 0.779	t = 0.880
Non-resident alien * female		0.057
		t = 0.802
Hispanic * female		−0.030
		t = −1.260
American Indian * female		0.021
		t = 0.389
Asian * female		0.025
		t = 0.817
Black * female		−0.057
		t = −1.191
Pacific Islander * female		−0.039
		t = −0.504
White * female		0.007

		t = 0.255
High school GPA * female		0.044
		t = 0.539
Admission index * female		−0.0001
		t = −0.016
Cohort Year 2012 * female		−0.006
		t = −0.378
Cohort Year 2013 * female		−0.002
		t = −0.124
Test Performance Math (SAT scale) * female		0.0001
		t = 0.437
Test Performance Total (SAT scale) * female		−0.0002
		t = −0.757
Constant	0.167***	0.154***
	t = 3.834	t = 2.816
Observations	3,683	3,683
R^2	0.018	0.023
Adjusted R^2	0.015	0.015
Residual Std. Error	0.189 (df = 3668)	0.188 (df = 3655)
F Statistic	4.883*** (df = 14; 3668)	3.128*** (df = 27; 3655)

Note: *p<0.1; **p<0.05; ***p<0.01
2-regression F-statistic: 1.233
2-regression p-value: 0.248

For regression set A, the 2-regression F-statistic is 1.145, with a p-value of 0.312. Because it is not less than the critical p-value of 0.05 we do not reject the null hypothesis that the unconstrained equation (with interaction effects) is not better than the constrained equation. The unconstrained equation does not provide statistically significantly better explanatory power of the data. Therefore, we will use the constrained equation to represent gender differences for regression set A.

Constrained regression A uses only the set of variables in equation 1 labeled "student characteristics". This is due to the fact that the dependent variable occurs at a time period before students have taken an courses at all at CU (at admit). The values presented in column 1 of table 9 represent all of the student characteristics variables. None of the β values are statistically significant for this constrained equation. Therefore we cannot say anything specific about the impact of these controls.

Let us now turn our attention to the gender term in constrained regression A. Here, $\beta_G = -0.020$ which is significant to the $p < 0.01$ level. Therefore, we reject the null hypothesis that $\beta_G = 0$, or that gender has no significant effect on whether a student declares economics as a major upon admission to CU. Another way of saying this is that women in our sample declare economics at a two percentage point change compared to men who are identical in all other ways. In fall, 6% of men declare economics in this sample. Therefore a two percentage point change would leave women declaring economics 4% of the time, a difference that is statistically significant.

Explicitly, for men: 65% of the student in the Principles of Microeconomics classroom are men. 6% of these men declare economics as a major. Therefore 3.9% of the Principles of Microeconomics course is male. Similarly 35% of the students in Principles of Microeconomics classroom are female. 4% of these women declare economics as a major. Therefore 1.4% of female students in the Principles of Microeconomics class are female. In order to see how this leads to a leaky pipeline, let us consider a few ratios:

- In the Principles of Microeconomics classroom: 1.85 males: 1 female
- Econ majors in Principles of Micro classroom: 2.71 males: 1 female

We can see a potential pathway for women emerging. The gender gap of two percentage points is present for the whole sample upon admission before students have taken economics courses at CU. Recall from the descriptive statistics that only 35% of freshmen taking Principles of Economics are women. Regression A tells us that these women are 2% less likely to declare economics as a major upon admission. An already dramatic gender gap worsens before freshmen even enter Principles of Microeconomics.

Regression B

The sample for regression B is comprised of all freshmen who declared economics as a major upon admission to CU in the 2011, 2012, and 2013 academic years and took a Principles of Microeconomics course. The dependent variable represents whether or not the student continues to declare economics as a major at the end of the fall semester.

Table 10: Regression Set B

	Dependent variable:	
	Economics declared at fall	
	(1)	(2)
Female	−0.026	−5.833*
	t = −0.282	t = −1.832
Non-resident alien	0.123	0.183
	t = 0.468	t = 0.503
Hispanic	−0.051	−0.111
	t = −0.477	t = −0.962
American Indian	0.399	0.389
	t = 1.025	t = 0.984
Asian	−0.050	−0.146
	t = −0.280	t = −0.763
Black	0.068	0.059
	t = 0.363	t = 0.315
Pacific Islander	−0.588	−0.477
	t = −1.481	t = −1.181
White	−0.023	−0.005
	t = −0.178	t = −0.033
High school GPA	−0.360	−0.739
	t = −0.753	t = −1.448
Admission index	0.018	0.039
	t = 0.675	t = 1.388
Cohort Year 2012	0.081	0.107
	t = 1.005	t = 1.230
Cohort Year 2013	−0.150*	−0.194**
	t = −1.723	t = −2.083
Test Performance Math (SAT scale)	0.0003	0.0002
	t = 0.414	t = 0.191
Test Performance Total (SAT scale)	−0.001	−0.002
	t = −0.799	t = −1.284
Lower Math	0.017	0.052
	t = 0.210	t = 0.596
Upper Math	0.197	0.164
	t = 0.939	t = 0.786
Grade received in Microeconomics	0.022	0.053
	t = 0.462	t = 0.999
Best grade	0.006	−0.021
	t = 0.121	t = −0.372
FCQ: Course Overall	0.009	−0.003
	t = 0.131	t = −0.039
FCQ: Prior Interest	−0.320**	−0.362***
	t = −2.585	t = −2.647
Female professor	−0.076	−0.135

	t = −1.011	t = −1.636
Non-resident alien * female		−1.079
		t = −1.393
Hispanic * female		0.706
		t = 1.548
Asian * female		2.826***
		t = 2.645
White * female		1.599*
		t = 1.915
High school GPA * female		8.221**
		t = 2.293
Admission index * female		−0.443**
		t = −2.308
Cohort Year 2012 * female		0.095
		t = 0.238
Cohort Year 2013 * female		0.079
		t = 0.192
Test Performance Math (SAT scale) * female		0.0002
		t = 0.076
Test Performance Total (SAT scale) * female		0.023**
		t = 2.318
Lower Math * female		−0.325
		t = −0.923
Grade received in Microeconomics * female		−0.002
		t = −0.005
Best grade * female		−0.061
		t = −0.175
FCQ: Course Overall * female		−0.205
		t = −0.586
FCQ: Prior Interest * female		0.037
		t = 0.099
Female professor * female		1.592**
		t = 2.436
Constant	2.255***	2.390***
	t = 3.357	t = 3.336
Observations	138	138
R^2	0.151	0.284
Adjusted R^2	−0.003	0.018
Residual Std. Error	0.338 (df = 116)	0.335 (df = 100)
F Statistic	0.982 (df = 21; 116)	1.069 (df = 37; 100)

Note: *p<0.1; **p<0.05; ***p<0.01
2-regression F-statistic: 0.636
2-regression p-value: 0.9

For regression set B, the 2-regression F-statistic is 0.597, with a p-value of 0.931. Because it is not less than the critical p-value of 0.05 we do not reject the null hypothesis that the unconstrained equation (with interaction effects) is not better than the constrained equation. The unconstrained equation does not provide statistically significantly better explanatory power of the data. Therefore, we will use the constrained equation to represent gender differences for regression set B.

Furthermore the variable "FCQ prior interest" offers a surprising result for these students who declared economics upon admit: a one point increase in "FCQ prior interest" correlated with a 32% decrease in the likelihood that the student will remain an economics major at the end of the semester. This comes from the constrained regression B, where $\beta_{FCQ} = -0.320$ which is significant to the $p < 0.05$. The aggregate effect of taking Principles of Microeconomics on the (male and female) students who declared economics upon admission is a 32% reduction in the number of students declaring economics. The "best grade" variable also offers a surprising and statistically significant result ($p < 0.05$) with a BETA VALUE of 0.011 indicating that a one letter grade increase in the student's best grade led to a 1.1 percentage point increase in declaring economics as a major during the fall.

For constrained regression B, $\beta_G = -0.026$ which is not significant to the $p < 0.10$. Therefore, we fail to reject the null hypothesis that $\beta_G = 0$ (that gender has no significant effect on who had already declared economics as a major in fall). Even though β_G suggests that women are more likely to drop economics at the end of the fall semester after declaring economic upon admittance, we cannot say this with confidence.

There does not appear to be a strong effect of gender on the choice of declaring economics in fall for students who declared economics upon admissions.

Regression C

The sample for regression C is comprised of all freshmen who did not declare economics as a major upon admission to CU in the 2011, 2012, and 2013 academic years but took a Principles of Microeconomics course. The dependent variable represents whether or not the student declares economics as a major for the first time at the end

of the fall semester.

Table 11: Regression Set C

	Dependent variable:	
	Economics declared at fall	
	(1)	(2)
Female	0.007	0.079
	t = 1.382	t = 0.811
Non-resident alien	−0.028	−0.025
	t = −1.166	t = −0.870
Hispanic	0.007	0.013
	t = 0.829	t = 1.202
American Indian	0.011	0.002
	t = 0.663	t = 0.099
Asian	0.017	0.036***
	t = 1.554	t = 2.597
Black	0.004	0.021
	t = 0.248	t = 1.006
Pacific Islander	−0.030	−0.039
	t = −1.106	t = −1.035
White	−0.004	0.004
	t = −0.346	t = 0.276
High school GPA	−0.099***	−0.084**
	t = −3.429	t = −2.218
Admission index	0.004***	0.004*
	t = 2.775	t = 1.894
Cohort Year 2012	0.016***	0.015**
	t = 2.870	t = 2.138
Cohort Year 2013	0.011*	0.019***
	t = 1.819	t = 2.591
Test Performance Math (SAT scale)	0.0001	0.00002
	t = 1.604	t = 0.341
Test Performance Total (SAT scale)	−0.0002***	−0.0002
	t = −2.612	t = −1.595
Admit major: Pol Sci	0.050***	0.032*
	t = 3.308	t = 1.721
Admit major: Env Studies	0.013	0.014
	t = 0.924	t = 0.846
Admit major: Int'l Studies	0.016	−0.018
	t = 0.895	t = −0.678
Admit major: B-School	−0.035***	−0.039***
	t = −6.911	t = −6.066
Lower Math	0.029***	0.032***
	t = 5.508	t = 4.891
Upper Math	−0.026*	−0.022
	t = −1.934	t = −1.423
Grade received in Microeconomics	0.011***	0.011***

	t = 3.429	t = 2.894
Best grade	−0.010**	−0.011**
	t = −2.487	t = −2.307
FCQ: Course Overall	0.001	−0.002
	t = 0.252	t = −0.387
FCQ: Prior Interest	0.004	0.011
	t = 0.573	t = 1.095
Female professor	0.004	−0.002
	t = 0.572	t = −0.243
Non-resident alien * female		−0.006
		t = −0.111
Hispanic * female		−0.018
		t = −1.031
American Indian * female		0.037
		t = 0.975
Asian * female		−0.052**
		t = −2.358
Black * female		−0.046
		t = −1.323
Pacific Islander * female		0.028
		t = 0.507
White * female		−0.017
		t = −0.817
High school GPA * female		−0.033
		t = −0.560
Admission index * female		0.001
		t = 0.229
Cohort Year 2012 * female		0.003
		t = 0.274
Cohort Year 2013 * female		−0.025**
		t = −2.030
Test Performance Math (SAT scale) * female		0.0002
		t = 1.571
Test Performance Total (SAT scale) * female		−0.0001
		t = −0.507
Admit major: Pol Sci * female		0.063*
		t = 1.910
Admit major: Env Studies * female		−0.002
		t = −0.064
Admit major: Int'l Studies * female		0.061*
		t = 1.706
Admit major: B-School * female		0.013
		t = 1.179
Lower Math * female		−0.011
		t = −1.051
Upper Math * female		−0.017
		t = −0.535

Grade received in Microeconomics * female		−0.003
		t = −0.452
Best grade * female		0.005
		t = 0.570
FCQ: Course Overall * female		0.009
		t = 0.993
FCQ: Prior Interest * female		−0.019
		t = −1.156
Female professor * female		0.018
		t = 1.280
Constant	0.048	0.019
	t = 1.057	t = 0.330
Observations	3,545	3,545
R^2	0.037	0.045
Adjusted R^2	0.031	0.032
Residual Std. Error	0.133 (df = 3519)	0.133 (df = 3495)
F Statistic	5.469*** (df = 25; 3519)	3.372*** (df = 49; 3495)

Note: *p<0.1; **p<0.05; ***p<0.01
2-regression F-statistic: 1.133
2-regression p-value: 0.294

For regression set C, the 2-regression F-statistic is 1.089, with a p-value of 0.344. Because it is not less than the critical p-value of 0.05 we do not reject the null hypothesis that the unconstrained equation (with interaction effects) is not better than the constrained equation. The unconstrained equation does not provide statistically significantly better explanatory power of the data. Therefore, we will use the constrained equation to represent gender differences for regression set C.

For constrained regression C, $\beta_G = 0.007$, which is not significant to the $p < 0.10$ level. Therefore, we fail to reject the null hypothesis that $\beta_G = 0$, or that gender has no significant effect on whether a student declared economics in fall after not having declared economics upon admissions. In other words, gender does not seem to be a reliable predictor of whether someone will switch into economics for the first time at the end of the fall semester.

There are some very strong indicators in the controls, however. Academic performance outside the classroom, both in high school (High school GPA: $\beta_{GPA} = -0.099$, which is significant to the $p < 0.01$ level) and during the fall semester (best grade: $\beta_{GPA} = -0.010$, which is significant to the $p < 0.05$ level) both indicate that better performance in other subjects leads to a decreased likelihood that freshmen will declare economics as a major at CU. Upper math, which indicates co-enrollment or completion of a calculus course, is also negatively correlated with the decision to major in economics for those who do not declare economics upon admission (upper math: $\beta_{UM} = -0.026$, which is significant to the $p < 0.10$ level).

Two control variables are positively correlated with the likelihood that a student will switch into economics in the fall semester. Course grade (course grade: $\beta_{GPA} = 0.011$, which is significant to the $p < 0.01$ level) and lower math (lower math: $\beta_{GPA} = 0.029$, which is significant to the $p < 0.05$ level) both lead to a higher likelihood that a student will switch into economics in the fall semester. These results conform to expectations that a basic understanding and better performance in Principles of Microeconomics would increase a student's incentive to declare economics as a major.

Regression D

The sample for regression D is comprised of all students in the sample who declare economics as a major upon admission to CU, and continued to declare economics as a major in the fall semester. The dependent variable represents whether or not the student declares economics as a major for the third time at the end of the third semester.

Table 12: Regression Set D

	Dependent variable:	
	Economics declared at spring	
	(1)	(2)
Female	0.197	−13.994
	t = 1.596	t = −0.895
Non-resident alien	−0.044	0.115
	t = −0.133	t = 0.241
Hispanic	0.147	0.124
	t = 1.003	t = 0.732
American Indian	0.263	0.260
	t = 0.535	t = 0.497
Asian	0.206	0.092
	t = 0.872	t = 0.345
Black	0.352	0.387
	t = 1.503	t = 1.585
White	0.151	0.112
	t = 0.864	t = 0.568
High school GPA	0.995	0.982
	t = 1.601	t = 1.439
Admission index	−0.061*	−0.061
	t = −1.748	t = −1.604
Cohort Year 2012	0.018	0.086
	t = 0.165	t = 0.708
Cohort Year 2013	0.010	0.021
	t = 0.086	t = 0.160
Test Performance Math (SAT scale)	0.001	0.001
	t = 0.848	t = 0.506
Test Performance Total (SAT scale)	0.003	0.003
	t = 1.496	t = 1.472
Lower Math	0.122	0.145
	t = 1.139	t = 1.155
Upper Math	0.167	0.136
	t = 0.635	t = 0.499
Grade received in Microeconomics	0.046	0.078
	t = 0.696	t = 1.042
Best grade	0.007	−0.014
	t = 0.097	t = −0.184
FCQ: Course Overall	0.169*	0.241**
	t = 1.810	t = 2.213
FCQ: Prior Interest	−0.107	−0.264
	t = −0.645	t = −1.395
Female professor	0.126	0.105
	t = 1.279	t = 0.930
Non-resident alien * female		−2.186

		t = −1.266
Hispanic * female		1.327
		t = 1.206
Asian * female		4.820*
		t = 1.704
White * female		2.733
		t = 1.442
High school GPA * female		6.615
		t = 1.114
Admission index * female		−0.394
		t = −1.199
Cohort Year 2012 * female		−0.579
		t = −0.965
Cohort Year 2013 * female		−0.323
		t = −0.513
Test Performance Math (SAT scale) * female		0.003
		t = 0.584
Test Performance Total (SAT scale) * female		0.024
		t = 1.302
Lower Math * female		−0.151
		t = −0.195
Grade received in Microeconomics * female		−0.929
		t = −0.905
Best grade * female		0.331
		t = 0.290
FCQ: Course Overall * female		−0.137
		t = −0.158
FCQ: Prior Interest * female		1.635
		t = 1.302
Female professor * female		1.340
		t = 1.105
Constant	−0.447	−0.317
	t = −0.497	t = −0.326
Observations	120	120
R^2	0.123	0.229
Adjusted R^2	−0.055	−0.105
Residual Std. Error	0.419 (df = 99)	0.429 (df = 83)
F Statistic	0.691 (df = 20; 99)	0.685 (df = 36; 83)
Note:		*p<0.1; **p<0.05; ***p<0.01
		2-regression F-statistic: 0.375
		2-regression p-value: 0.996

For regression set D, the 2-regression F-statistic is 0.35, with a p-value of 0.998. Because it is not less than the critical p-value of 0.05 we do not reject the null hypothesis that the unconstrained equation (with interaction effects) is not better than the constrained equation. The unconstrained equation does not provide statistically significantly better explanatory power of the data. Therefore, we will use the constrained equation to represent gender differences for regression set D.

Only two controls are significant for regression D. Index, which represents how desirable a student is to the university at admit, is negatively correlated with the likelihood that students will continue to study economics at the end of the second semester (index: $\beta_I = -0.061$, which is significant to the $p < 0.10$ level) is negatively correlated with the outcome of students declaring economics for the third time (in spring of their freshman year). Additionally, rating of the Principles of Microeconomics course on FCQs is positively correlated with students declaring economics in the spring, if they have already declared economics upon admit and in fall. This result is very intuitive: students are more likely to declare economics if they report a positive experience of the course overall.

For constrained regression D, β_G is not significant to the $p < 0.10$. Therefore, we fail to reject the null hypothesis that $\beta_G = 0$, or that gender has no significant effect on whether a student persists in the study of economics past the spring semester. In other words, gender is not a reliable predictor of whether students will persist in declaring economics as a major if they have already done so at admit and in fall. Regardless of gender, students in this category generally persist in their study of economics through the spring semester.

Regression E

The sample for regression E is comprised of all students in the sample who declare economics as a major upon admission to CU, and did not declare economics in the fall semester. The dependent variable represents whether or not the student declares economics as a major end of the spring semester. Only 18 observations are available for this pathway. This regression is not included in this study.

Regression F

The sample for regression F is comprised of all students in the sample who do not declare economics as a major upon admission to CU, but do declare economics in the spring. The dependent variable represents whether or not the student declares economics as a major for second time at the end of the spring semester. Only 56 observations are available for this pathway. This regression is not included in this study.

Regression G

The sample for regression G is comprised of all students in the sample who do not declare economics as a major upon admission to CU or at the end of fall semester after taking a CU Principles of Economics course. The dependent variable represents whether or not the student declares economics as a major for the first time at the end of the spring semester.

Table 13: Regression Set G

	Dependent variable:	
	Economics declared at spring	
	(1)	(2)
Female	−0.012**	−0.096
	t = −2.054	t = −0.871
Non-resident alien	−0.006	0.011
	t = −0.242	t = 0.346
Hispanic	0.016*	0.021*
	t = 1.677	t = 1.730
American Indian	0.032*	0.030
	t = 1.683	t = 1.341
Asian	0.032***	0.044***
	t = 2.600	t = 2.751
Black	0.025	0.018
	t = 1.306	t = 0.752
Pacific Islander	−0.036	−0.052
	t = −1.183	t = −1.245
White	0.010	0.023
	t = 0.857	t = 1.519
High school GPA	0.006	−0.008
	t = 0.175	t = −0.179
Admission index	−0.001	0.0001
	t = −0.601	t = 0.035
Cohort Year 2012	0.017***	0.022***
	t = 2.723	t = 2.748
Cohort Year 2013	0.004	0.003
	t = 0.541	t = 0.371
Test Performance Math (SAT scale)	−0.0001**	−0.0002***
	t = −2.344	t = −2.977
Test Performance Total (SAT scale)	0.00004	−0.00001
	t = 0.353	t = −0.081
Admit major: Pol Sci	−0.028	−0.047**
	t = −1.586	t = −2.222
Admit major: Env Studies	−0.035**	−0.040**
	t = −2.261	t = −2.044
Admit major: Int'l Studies	−0.045**	−0.054*
	t = −2.223	t = −1.834
Admit major: B-School	−0.038***	−0.047***
	t = −6.532	t = −6.428
Lower Math	−0.006	−0.007
	t = −1.033	t = −0.890
Upper Math	0.065***	0.065***
	t = 4.316	t = 3.742
Grade received in Microeconomics	0.009***	0.010**

	t = 2.715	t = 2.255
Best grade	0.001	−0.0004
	t = 0.223	t = −0.067
FCQ: Course Overall	0.004	0.005
	t = 0.773	t = 0.870
FCQ: Prior Interest	0.003	−0.003
	t = 0.354	t = −0.311
Female professor	−0.006	−0.013
	t = −0.803	t = −1.356
Non-resident alien * female		−0.051
		t = −0.862
Hispanic * female		−0.015
		t = −0.790
American Indian * female		0.012
		t = 0.268
Asian * female		−0.033
		t = −1.327
Black * female		0.029
		t = 0.738
Pacific Islander * female		0.040
		t = 0.646
White * female		−0.034
		t = −1.408
High school GPA * female		0.048
		t = 0.697
Admission index * female		−0.004
		t = −1.039
Cohort Year 2012 * female		−0.011
		t = −0.825
Cohort Year 2013 * female		0.001
		t = 0.103
Test Performance Math (SAT scale) * female		0.0002*
		t = 1.767
Test Performance Total (SAT scale) * female		0.0002
		t = 0.833
Admit major: Pol Sci * female		0.064
		t = 1.643
Admit major: Env Studies * female		0.013
		t = 0.407
Admit major: Int'l Studies * female		0.025
		t = 0.614
Admit major: B-School * female		0.024**
		t = 1.968
Lower Math * female		0.001
		t = 0.051
Upper Math * female		0.001
		t = 0.024

Grade received in Microeconomics * female		−0.002
		t = −0.251
Best grade * female		0.006
		t = 0.587
FCQ: Course Overall * female		−0.004
		t = −0.346
FCQ: Prior Interest * female		0.016
		t = 0.869
Female professor * female		0.021
		t = 1.307
Constant	0.123**	0.149**
	t = 2.378	t = 2.326
Observations	3,479	3,479
R^2	0.043	0.048
Adjusted R^2	0.036	0.034
Residual Std. Error	0.149 (df = 3453)	0.149 (df = 3429)
F Statistic	6.139*** (df = 25; 3453)	3.530*** (df = 49; 3429)

Note: *p<0.1; **p<0.05; ***p<0.01
2-regression F-statistic: 0.787
2-regression p-value: 0.763

For regression set G, the 2-regression F-statistic is 0.756, with a p-value of 0.807. Because it is not less than the critical p-value of 0.05 we do not reject the null hypothesis that the unconstrained equation (with interaction effects) is not better than the constrained equation. The unconstrained equation does not provide statistically significantly better explanatory power of the data. Therefore, we will use the constrained equation to represent gender differences for regression set G.

For constrained regression G, β_G is not significant to the $p < 0.10$. Therefore, we fail to reject the null hypothesis that $\beta_G = 0$, or that gender has no significant effect on whether a student chooses to major in economics for the first time at the end of the spring semester.

7 Conclusion

The results from this study are mixed. Regression A demonstrated that a clear, statistically significant gender gap exists for freshmen taking Principles of Microeconomics at CU Boulder. Female students with identical characteristics to their male counterparts are two percentage points less likely to declare economics when entering the university, This leaves the economics department in a tricky position to try to win over an already more reluctant group. This study demonstrates that the holes in the "leaky pipeline" are actually relatively small when it comes to the women's experience in Principles of Economics in their first year of school. Only the regression that does not characterize student performance or experience at CU has a statistically significant beta value for gender.

However this study does confirm that the gender imbalance in CU's classroom does start at a much earlier age. The strongest effect is seen at admission, when the economics department could make a more substantial effort to attract women. Further study is necessary to see if there is additional loss in other courses at CU.

8 Limitations and Further Studies

The most substantial limitations from this study are related to the methodology. Because I chose to request data from the university's records I never had a chance to talk to the female students who are taking Introduction to Microeconomics. Several studies cited in the literature review successfully used surveys to construct datasets that represented margins of analysis that were simply not available using the methodology employed in this study.

Furthermore, there are many other methodologies that other researchers have used in studies that could further elucidate leaky pipeline issues in economics at CU Boulder. One successful methodology that could be interesting to study is a regression discontinuity design to test gender based grade sensitivity. The "best grade - course grade" variable was an interesting way to look at this question and validated the need for further study. However, this variable could not predict jumps in a trend surrounding discrete changes such as letter grade earned.

One strength of this methodology is its scalability. The time stratification/map of regressions presented in Figure 1 could easily be extended as a framework into high school, and beyond the first year of college. Within the leaky pipeline analysis it is apparent that the interconnectivity of human choice is one of the largest challenges to model. But this time stratification tool could fit into any scale for which a researcher has data.

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