The Gender Gap and Variation in Math Requirements for STEM Majors

Econ 1375: Inequality of Opportunity (2014)

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1 Introduction

Both economics papers and a quick walk around a college campus today show that there are far fewer women majoring in STEM (science, technology, engineering, and math) fields than men. Even within STEM fields, though, women are unevenly distributed. There is a body of research studying women and math that often concludes that women fall behind men in math achievement tests. This paper explores whether the variation in women across STEM majors correlates with the amount of math required by each major.

2 Background

Gemici and Wiswall note that while women today are more likely than men to graduate from college, they are still less likely to graduate in STEM and business-related majors. They show that for the 1963 birth cohort, 39% of men graduated in STEM, 31% in business, and 30% in humanities. For women born the same year, only 21% graduated in STEM, 29% in business, and 50% in humanities. Wiswall and Zafar ran an experiment asking students which field they would most likely study in college: engineering, natural science, business, or humanities. Men chose engineering 9% of the time, natural science 18% of the time, business 38% of the time, and humanities 32% of the time. Women chose engineering 5% of the time, natural science 16% of the time, business 27% of the time, and humanities 50% of the time. During the same experiment, after the students are asked what field they would choose, they are shown the median income of graduates in each field. Despite the lower income in Humanities, that field is still the most popular choice among women, although with a slightly smaller magnitude than before the income identification. This is problematic because the sex-based wage gap is, in part, caused by women not going into high-paying fields like engineering. Brown and Corcoran show that there are small differences in salaries for men and women when comparing graduates from the same major, but large differences in average salaries.

Previous economists have asked why fewer women choose STEM majors and the results are usually murky and inconclusive. The cause seems to be hidden in the culture of the United States and begins to affect children at a young age. Fargena and Joyce show that when girls and boys between the ages of 9 and 13 are asked to choose science classes for themselves and those of the opposite gender, both boys and girls overwhelmingly choose physical science and technology classes for boys and life science classes for girls. Cvencek, et al. show the bias appears even earlier: they test second graders who display both implicit and explicit biases that math is for boys.

I want to approach the question of why women choose humanities majors over STEM majors slightly differently: I will be looking at variation within STEM majors. Motivated by personal observations that my computer science classes often have an even larger gender disparity than biology classes, it seems like it is not the case that within STEM fields women are distributed equally. One source of variation among STEM majors is the amount of math the various majors require. Almost every STEM major requires some math, but it is not a constant across the discipline. In this paper I look to see if there is a correlation between the percent of women in a particular STEM major and the amount of math that major requires.

There is a fairly significant literature on women and math. Fryer and Levitt claim that while boys and girls enter kindergarten at the same level of math, by sixth grade, girls have lost 0.2 standard deviations of mathematical skill relative to boys. That is half of the black-white test score gap and equivalent to 2.5 months of schooling. Ellison and Swanson claim that Fryer and Levitt potentially over-estimate this gap for average students, but show that there is a large gap at higher levels of achievement. For example, they point out that there is a 2.1 to 1 male-female ratio among students who score 800 on the math SAT. In addition to papers on women‘s achievement in math, there is some research on womens confidence in their math skills. Wiswall and Zafar find that when asked on a scale of 1-100 where they would rank in ability compared to others in a particular major, women tend to think they have a lower relative ability compared to men. Marra and Bogue also say that womens self-efficacy about their ability in engineering curriculums drops as they go through the curriculum. Not all papers agree, though; Hackett and Betz claim they did not find evidence that women‘s mathematics self-efficacy was unrealistically low compared to mens.

To my knowledge, no one has linked the amount of math required in a subject and womens rates of graduation in that subject. This paper presents the following sections: information about data and data collection, methods and results, and conclusions and future goals.

3 Data

My analysis looks predominantly at the amount of math required for a major at a specific university and the percent of women in that major at that university. I chose to collect data on ten majors in twenty-five colleges in the US. Eight of the ten majors I chose to study are common majors that are representative of STEM fields: biology, chemistry, physics, computer science, environmental science, mechanical engineering, computer engineering, and math. I also look at data on two social science majors, economics and psychology. I chose economics because the amount of math varies widely across schools and psychology because it is traditionally female-dominated. The list of twenty schools I sample was chosen based on which schools had the most observations in the IPEDS survey I use. I did not use any online schools and attempted to choose

instnm	unitid	obereg	control	instsize	locale	cipcode	percentWomen	major	math_count
University of California-Irvine	110653	8	1	5	12	141901	0.184	mechanical engineering	6
University of California-Irvine	110653	8	1	5	12	400501	0.466666669	chemistry	3
University of California-Irvine	110653	8	1	5	12	400801	0.037037037	physics	6
University of California-Irvine	110653	8	1	5	12	260101	0.551681221	biology	2
University of California-Irvine	110653	8	1	5	12	110701	0.113636367	computer science	6
University of California-Irvine	110653	8	1	5	12	30104	0.699999988	environmental science	1
University of California-Irvine	110653	8	1	5	12	450601	0.342541426	economics	3
University of California-Irvine	110653	8	1	5	12	420101	0.677655697	psychology	1
University of California-Irvine	110653	8	1	5	12	140901	0.086956523	computer engineering	5
University of California-Irvine	110653	8	1	5	12	270101	0.397435904	mathematics	17

Figure 1: Sample data: $instnm$ = institution name, $unitid$ = id of instituion, $obereg$ = region code (8 is West), $control$ = public or private (1 is public), $instsize$ = size of instution (5 is largest), $locale$ = proximity to city (12 is medium city), $cipcode$ = major code, $percentWomen$ = percent of women in major, $major$ = major, $math\_count$ = number of math courses required for major

schools from a range of geographic regions within the US. The IPEDS survey is from 2013 and includes data on the percent of women in each major at each school and school characteristics, like region and size. I collect the data on the amount of math required for a major at a specific university from each university's website. I define the amount of math for a major to be the total number of math courses required for that major (not including a university's general education requirements). A course counts as a math course if it is in a math, applied math, or statistics department or if it has a traditional math title (i.e. Linear Algebra), even if it is not in a math department. I look for degree requirements valid in 2013, since that is the date of the IPEDS data.

4 Regressions and Results

I start by regressing the percent of a major that is women on the number of math courses in a major. I exclude the data about the mathematics major itself because the numbers are so different from every other major that it skews the results (i.e. the mean number of math courses for the mathematics major is 14.64 with a standard deviation of 2.87 while the mean number of math courses for non-mathematics majors is 3.39 with a standard deviation of 1.84). I find that every math course added to a major correlates with 8.5 percentage points fewer women in that major. The p-value is 0.000, so this result is statistically significant. This means that a one standard deviation increase in math classes in a major (again, not including data about the mathematics major) correlates with 15.6 percentage points fewer women graduating in that major. The total standard deviation for percent women across majors (excluding mathematics) is 24.5 percentage points, so this could explain up to 63.7% of the difference in quantity of women in a major. From an economics standpoint, this is significant. Note that I am not claiming any causal relationship, but there is clearly a strong correlation between the quantity of math courses required for a major and the percent of women who choose that major.

Next, I look to see if there is variation in the percent of women in a major across schools when the major is held constant and only the number of math courses varies. To do this, I create dummy variables for each major and regress the percent of women

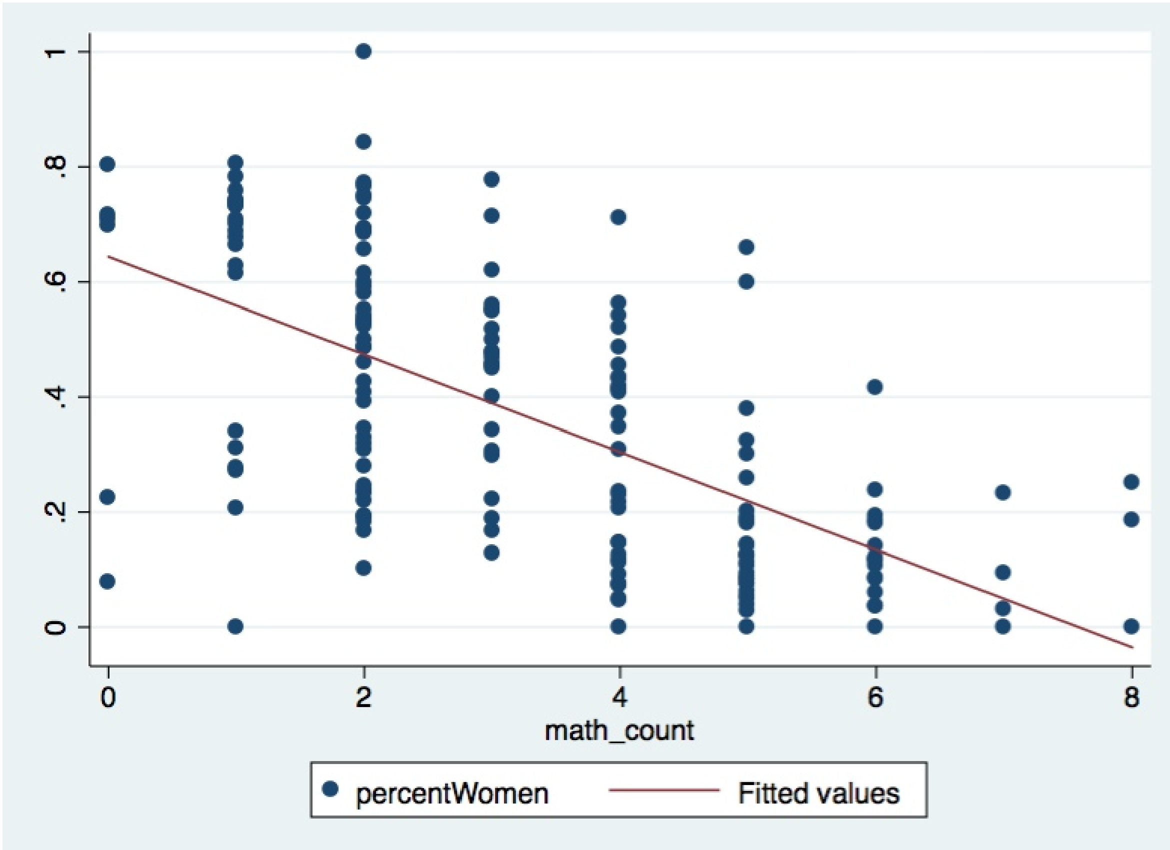

Figure 2: Regression of percent women in a major on number of math courses required for a major

in a major on the product of the dummy variable and number of math courses for a major. From a glance, six of the majors show a negative correlation less significant than the overall result and four show a positive correlation. The p-values for the F-statistics testing if the coefficients are significantly different from zero show, though, that only two of the results are important: environmental science, that suggests a 7.8 percentage point drop in the number of women for every math course added, and economics, that actually suggests a 4.3 percentage point increase in the number of women for every math course added. On a whole, this shows that fine-tuning the exact number of math courses required for a major does not affect the number of women in that major.

In my opinion, this does not contradict the overall finding that additional math

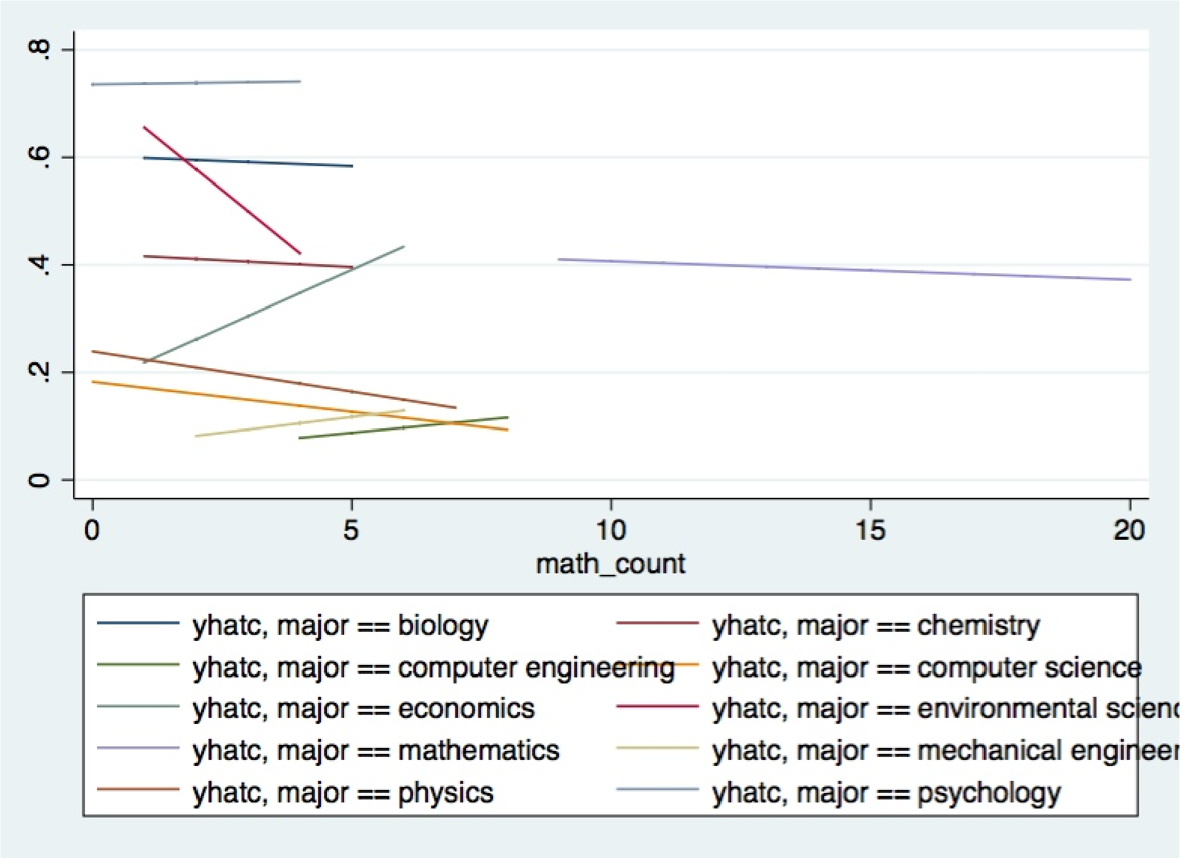

Figure 3: Regression of percent women in a major on number of math courses for that major conditional on major

courses correlate with far fewer women in a particular major. The exact number of math classes in a major is used in this paper as a proxy for the *mathiness* of the major. Other harder-to-measure factors also contribute to the *mathiness* of a major such as the perception of the level of math skill required to succeed in that major and the degree to which higher-level courses depend on introductory math skills. Therefore, rather than say women are not sensitive to small changes in the amount of math a major requires, it makes more sense to conclude that the exact number of courses required is not a perfect metric for the exact *mathiness* of a major.

Another way to get a good estimation of the mathiness of the major is to consider the average number of math courses for that major across schools and the average percent

Major	Coefficient	Prob > F =
Biology	-0.0075542	0.8434
Chemistry	-0.0050686	0.7742
Computer Engineering	0.0094512	0.6147
Computer Science	-0.0111149	0.4204
Economics	0.0430699	0.0076
Environmental Science	-0.0779218	0.0056
Mathematics	-0.0034453	0.586
Mechanical Engineering	0.0117058	0.5509
Physics	-0.015016	0.2167
Psychology	0.0013379	0.9412

Figure 4: Coefficients and p-values for regression of percent women in a major on number of courses required for that major conditional on major

women in that major across schools. This might smooth over some of the school-specific differences from the previous regression. Regressing average percent women on average math courses required does lead to a result that is even more extreme than the initial regression. Even to the naked eye, it is not hard to imagine a line through the data. For one additional math class, there is a 14.5 percentage point drop in women in that major (or a 21.4 percentage point drop for a one standard deviation increase in math courses). Note that, as before, I do not include data on the mathematics major.

Finally, I run the original regression again, percent women in a major on number of math courses in a major, but with added controls on school features. I control for region of the US, public versus private, school size (although this is omitted in the end because I use only data from very large schools), and urban versus suburban. Since each of these is a categorical variable, I run the regression with dummy variables for each combination of traits. I then use an F-test to test if the overall effect of each category is significant. The contribution of region is important (the p-value for the F-test is 0.0293) with the most significant region for increasing the percent of women in STEM

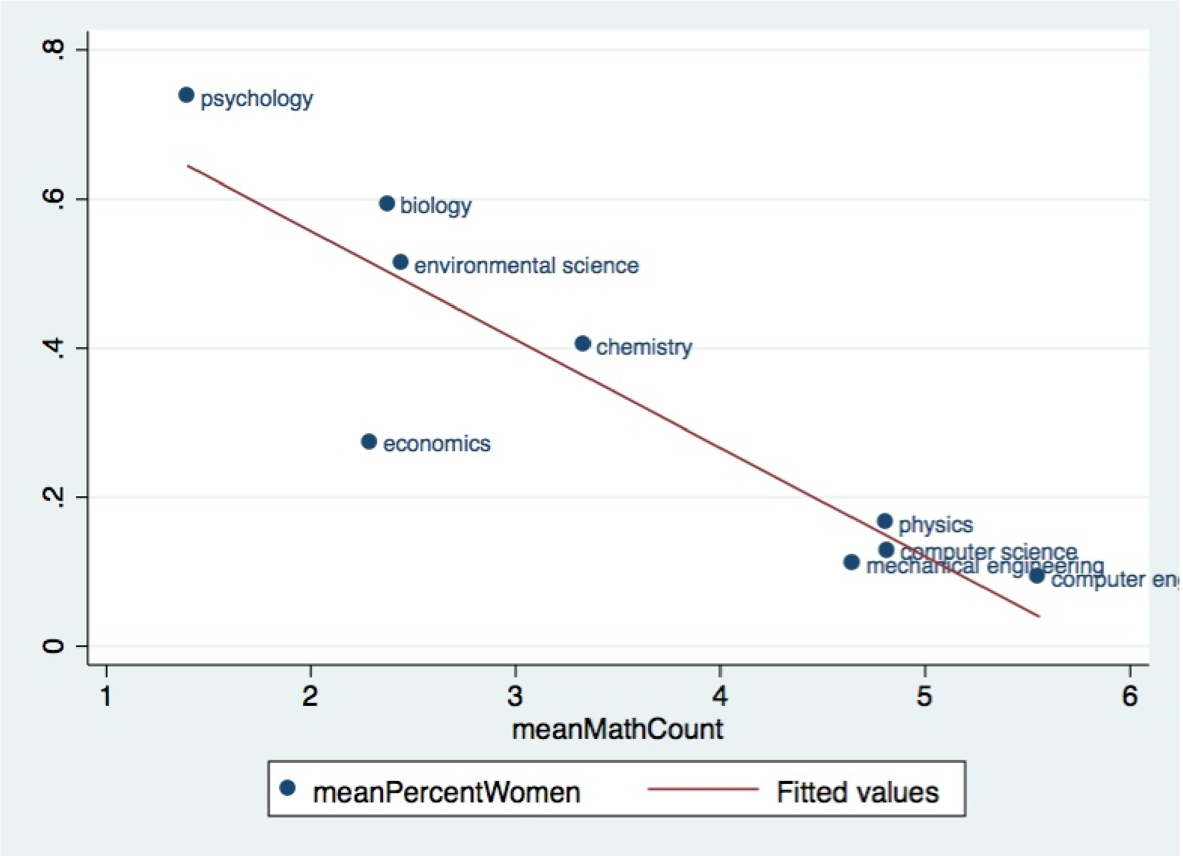

Figure 5: Regression of average percent women in a major on average number of courses required for that major

majors being the West. Whether a university is public or private is significant at the 10% level, with a boost in percent women in private not-for-profit schools. Whether a college is suburban or urban is insignificant. In this regression, one additional math course causes a 9.7 percentage point drop in women in a major, which is more than the initial 8.5 percentage point estimate.

5 Conclusion

Clearly, there is a correlation between the amount of math required for a major and the percent of that major that is made up of women. We saw earlier that women lose ground in math skills before college and sometimes show a lack of confidence in their knowledge. Maybe one, or both, of these factors causes women to shy away from math-intensive majors. While it would be depressing to conclude that women avoid STEM fields simply because of the math that is involved, it would also be hopeful because there are steps that could be taken to encourage women to pursue math. The initial findings from this paper might be a good starting point for more work on the role of math in womens course selections and career choices.

6 Future Goals

Making this study more meaningful, and maybe eventually showing a causal relationship, would require better data and further thought on several issues. The first step would be to collect more data. I only have data on twenty-five schools and ten majors. I do not think many more majors are needed, but it would be preferable to have a large body of schools to study. I was also very loose in what I called a math course. I would need to develop a stricter definition. I also wonder if courses that require math as a prerequisite should contribute to the mathiness score. For example, a biology major often requires calculus but advanced biology courses do not require a fundamental understanding of calculus. Physics, on the other hand, also requires calculus but it is an integral part of the rest of the major. Another concern to think about is that some, but not all, schools require students to apply to be in a major. I wonder if this application process causes a selection bias. This would be especially problematic if the selection process were biased towards men (which, given previous studies on science faculty and gender bias, like the one by Moss-Racusin, et al., is not unreasonable). Another issue I believe merits further research: perceived amount of math versus actual amount of math required. It would be interesting to create another index for *mathiness* based on perception of math required instead of actual number of math courses required. Finally, it would be important to control for more school characteristics. For example, the amount of diversity in the school, the percent of women in the overall population, the number of female professors in STEM majors, income levels, etc. could all contribute to whether a woman chooses a STEM major.

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