High School Curriculum Choice and College Major Choice: A Gender Gap?

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From NLSY 97, the gender gap in high school STEM achievement is shrinking fast. If anything, girls are outperforming boys in mathematics and life science. However, when it comes to major choice in college, significantly less girls choose STEM.

Math achievement is considered as one of the deciding factor in taking up STEM major, thus I want to examine how student's high school math affect their college choice.

There are a few "common sense" hypotheses.
(1) Preference Hypo:
Girls are less interested in Math, so they did not take up STEM.
(2) Competitive Advantage Hypo:
Girls are less competent in Math, so they did not take up STEM.

The preliminary data analysis on the NLSY 97 data shows that either hypothesis is good enough to answer this puzzle.

According to NECS 2003-01, high school math courses can be divided into four categories

- Non-academic:
- Low academic: algebra(informal), geometry(partial)
- Middle academic: geometry, algebra, unified math
- Advanced academic: probability, statistics, trigonometry, calculus

Within each category, there are further subgroups, here I will only discuss the advanced academic level,

- Adv 1: probability, statistics and trigonometry
- Adv 2: pre-calculus

- Adv 3: all calculus

From NLSY, there are more girls than boys are taking up the harder math classes. In the following tables, I report the percentage of take up over the whole population and over gender specific population. More girls than boys are taking up harder math classes, and girls are more likely than boys to take up harder math classes.

Course Level	Girl Pct, Uncond	Boy Pct, Uncond	Cond on Girl	Cond on Boy
Calculus	0.0513	0.0457	0.0951	0.0820
Adv Math	0.1192	0.0997	0.2210	0.1788
Middle	0.188	0.2045	0.3485	0.3667
Low	0.1809	0.2077	0.3353	0.3725

This could be a strong counter evidence to the preference hypothesis. Research([2]) has show that lack of interest and self-concept is much bigger problem among gifted girls than boys. But if that story is true, we should see less girls and less likely. An alternative explanation is that girls hate math, but it is a very good signal to college application so they take it up anyway.

Now let's take a look at the college major choice. Here the coding is the following

- STEM:
  Agriculture/Natural resources,
  Biological sciences,
  Computer/Information science,
  Engineering,
  Mathematics,
  Physical sciences,
  Automobile/Automotive Mechanics,
  Electrical/Electronics Maintenance,
  Geography,
  other sciences/applied sciences
- Humanity:
  Anthropology
  Area studies
  English
  Ethnic studies
  Foreign languages
  History
  Philosophy
  Theology/religious studies
  Liberal Arts and Sciences

- Econ :
  Business management
  Economics
  Home economics

- Social Science : Archaeology
  Communications
  Criminology
  Education
  Interdisciplinary studies
  Political science and government
  Pre-law
  Psychology
  Sociology
  International Relations and Affairs

- Med Related : Nursing
  Other health professions
  Pre-dental
  Pre-med
  Pre-vet
  Nutrition/Dietetics

- Other Architecture/Environmental design
  Fine and applied arts
  Hotel/Hospitality management
  Human Services, General
  Social Work
  transportation and materials moving
  security and protective services
  legal support services

- No college

Here is the distribution of college choice. There are less girls in STEM and girls are less likely to take STEM as their first choice of major.

Major	Girl Pct, Uncond	Boy Pct, Uncond	Cond on Girl	Cond on Boy
STEM	0.0331	0.0619	0.0677	0.1209
Humanity	0.0071	0.0058	0.0146	0.0113
Econ	0.0447	0.0462	0.0917	0.0902
Social Science	0.0745	0.0382	0.1526	0.0746
Medical Related	0.0521	0.0116	0.1067	0.0226
Other major	0.0151	0.0154	0.0310	0.0300
No College	0.2615	0.3329	0.5357	0.6504

So the logical conclusion is that girls who take hard math is less likely to stay in STEMs, which is confirmed by the data. Although the level of take up rate is higher for those who took harder math classes, the gender gap in retention rate is huge. Roughly speaking, the ratio is about 2:1 for those who take advanced math.

Math lv	gender	STEM	Humanity	Econ	Social Science	Pre-Med	Other	No College
Calc	female	0.182	0.033	0.139	0.221	0.095	0.037	0.293
Calc	male	0.36	0.022	0.153	0.083	0.022	0.041	0.319
Adv	female	0.146	0.035	0.122	0.239	0.12	0.035	0.304
Adv	male	0.265	0.024	0.183	0.104	0.03	0.041	0.354
Mid	female	0.052	0.008	0.09	0.152	0.117	0.034	0.548
Mid	male	0.112	0.01	0.078	0.081	0.029	0.03	0.661
Low	female	0.033	0.008	0.073	0.097	0.087	0.026	0.676
Low	male	0.061	0.007	0.058	0.055	0.013	0.024	0.782

Why is that?

Here the competitive advantage hypothesis kicks in. Maybe at the far right tails, there are less girls than boys. This explanation has two problems. First of all, going STEM does not require to be the far right tail. Second of all, it is not a clear cut that girls are inferior to boys at the right tail.

If one looks at the GPA, girls are doing better than boys. If one looks at the SAT, boys are doing better than girls. The inconsistency maybe due to the fact that girls under perform in competitive environment([1]). Figure 1 shows the difference of SAT score and the GPA. It must be a great set back for all those girls in the right tail of math GPA but got a mediocre SAT score. If we know girl are less confident in math in the first place, then they are hit with an unexpectedly lousy SAT score, does that discourage them from choosing the STEM major?

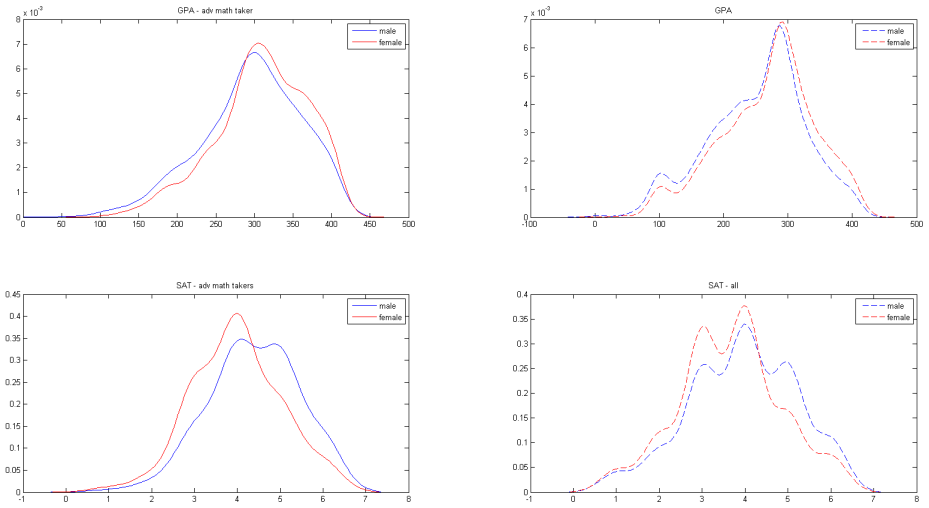

Figure 1: Comparison of GPA and SAT in Math

However, there is one difficulty in blaming the competitive environment. If we look at the verbal section of SAT and english GPA, one could observe almost the same pattern. If it is a confidence story, then why that does not deter girls from choosing humanity?

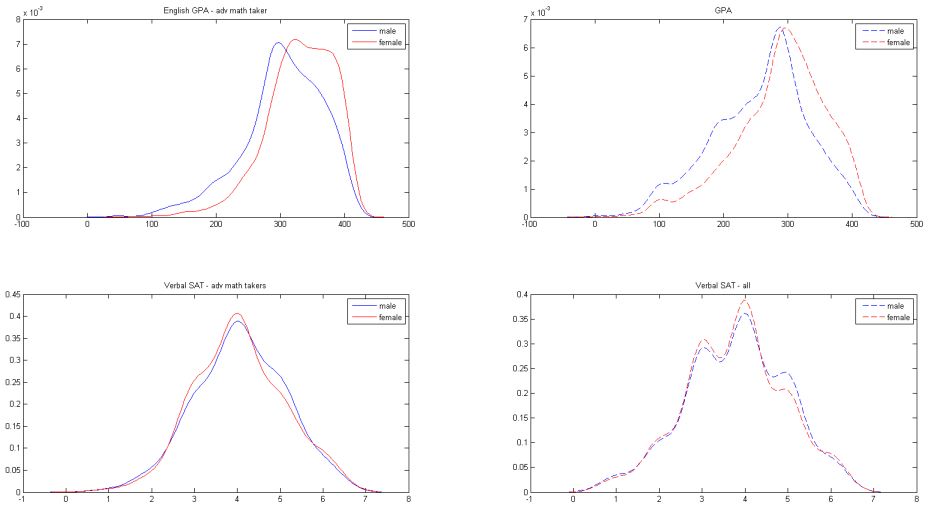

Figure 2: Comparison of GPA and SAT in Verbal

Gender gap is usually associated with SAT score[3]. However, because girl tends to under-perform in a competitive test, it is not clear if SAT is the right place to look for gender gap. Granted, GPA could be a lousy measurement of math achievement itself. If we look at the GPA for English, Social science and Math, girls who end up in STEM is consistently at the top of the game.

However, there is an cautionary tale. For those who did not go to college, the GPA distribution is similar to the college kids. This suggests that school quality is an important aspect of the GPA measurement error. It could be worse school just systemically inflate the grades, which distorted the GPA distribution. However, for that to reconcile the GPA - SAT distribution, one would have to assume that girls systemically attend worse school than boys, which is quite dubious as well.

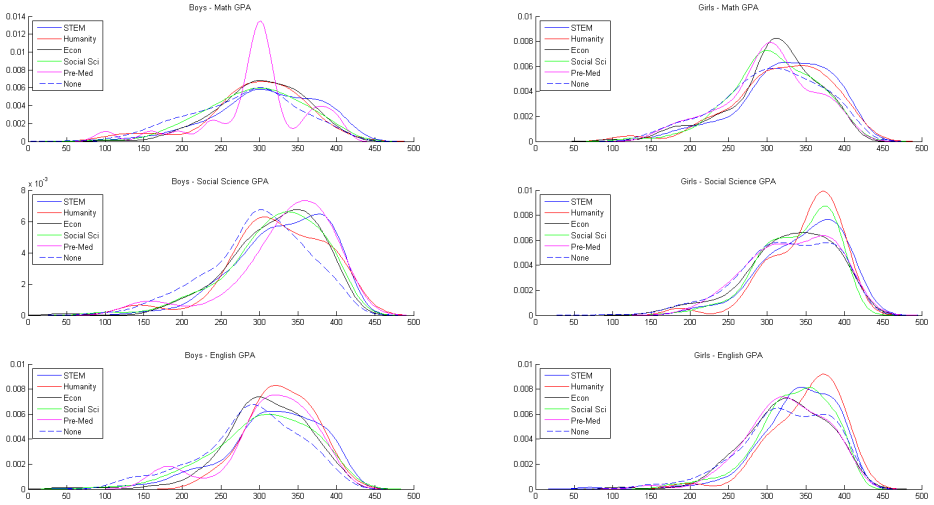

Figure 3: GPA scores by college major among adv academic group

If we compare the GPA and SAT by the college major, a similar pattern emerges. The boys' math achievement does not shift a lot, but girls' is dramatically different , especially at the right tail. If we look at the GPA, those who stay in STEM is the highest math achiever on average. However, if we look at the SAT, the average highest achiever is actually girls who choose humanity.

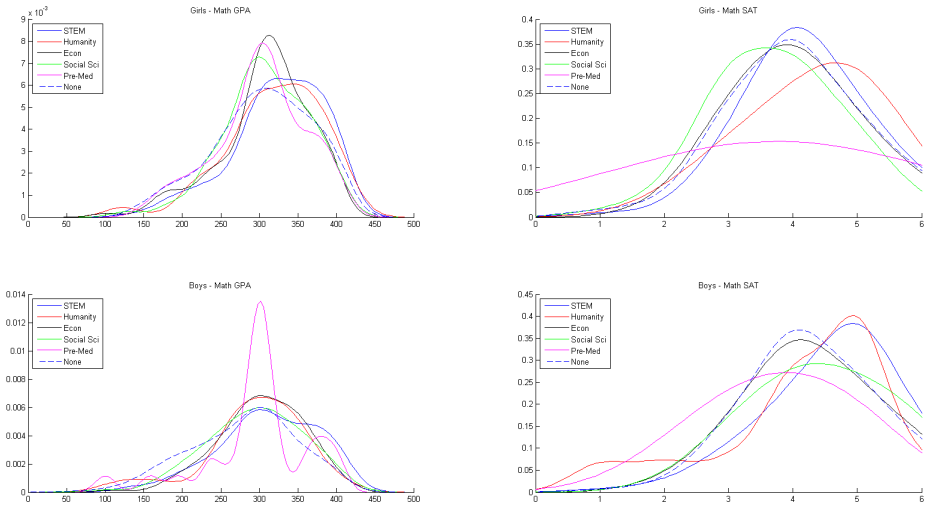

Figure 4: Comparison of Math GPA and SAT by college major among adv academic group

Similar Pattern, albeit at a lesser degree is observed in verbal section. For those who stay in STEM, the verbal SAT is way worse than their english score.

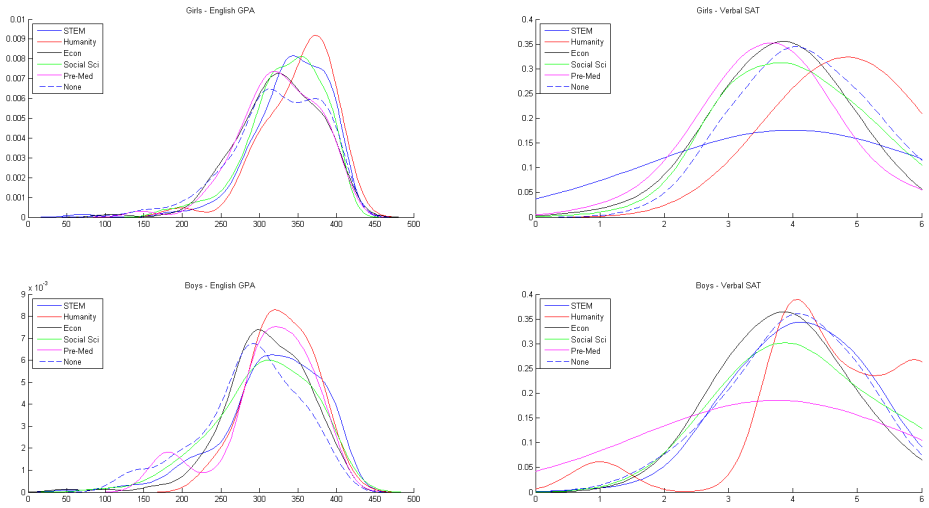

Figure 5: Comparison of English GPA and Verbal SAT by college major among adv academic group

I think such large discrepancy may affect their college major choice. I would guess that students will divert from the area that they got a larger negative shock. If this theory holds, girls who choose STEM will have a larger negative shock in humanity while girls who choose humanity will have a larger shock in math. However, if we measure the negative shock as the difference in the quantile ranking, the data does not quite support this theory. Every major appears to have similar negative shock. Although, to be fair, girls who choose econ does have a relative larger shock in math than in verbal.

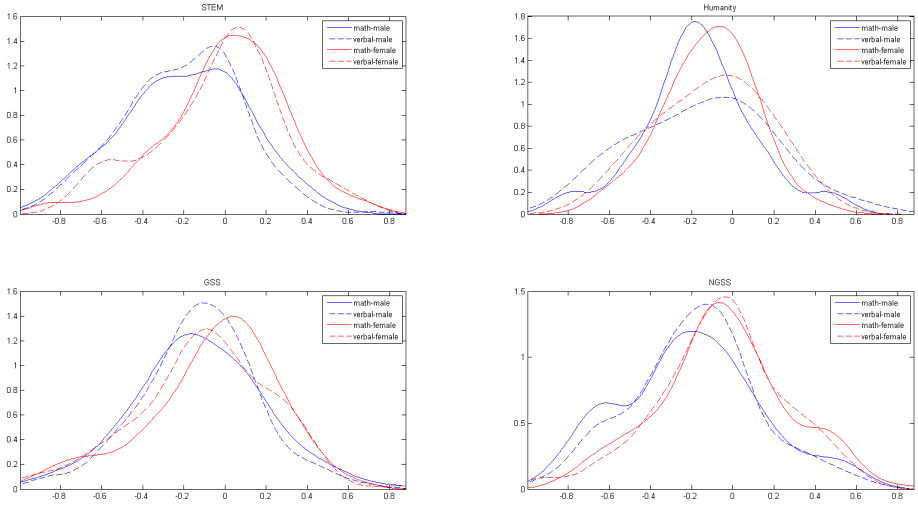

Figure 6: Comparison of English GPA and Verbal SAT by college major among adv academic group

References

[1] Muriel Niederle and Lise Vesterlund, "Explaining the Gender Gap in Math Test Scores: The Role of Competition", *Journal of Economic Perspective*, Volume 24, Number 2, Spring 2010, p.129-144

[2] Franzis Preckel, Thomas Goetz, Reinhard Pekrun and Michael Kleine, "Gender Difference in Gifted and Average Ability Students: Comparing Girls' and Boys' Achievement, Self-Concept, Interest and Motivation in Mathematics", *Gifted Child Quarterly*, 2008 52:146

[3] Roland G.Fryer, Jr., Steven D. Levitt, "An Empirical Analysis of the Gender Gap in Mathematics", NBER working paper 15430