STEM Degree Attainment and Gender Wage Gap in China: Segregation in Fields of Study or Heterogeneous Returns?

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Abstract

A reversal of gender gap in access to higher education is spotted in China, as a result of industrialization and tertiary education expansion, as well as spreading gender-egalitarian social norms. In the meantime, however, the level of gender segregation in fields of study–with the key feature of female underrepresentation in Science, Technology, Engineering, and Math (STEM) majors–kept rising. Gender segregation, though is not caused by pure discrimination, contributes to gender gaps in individuals' labor market outcomes: we find that tertiary education majors explain about 10% of the gender wage gap for college graduates, even after controlling for respondents' cognitive skills, family socioeconomic status, college qualities, and working experience. The main channel for the effect of college major on gender wage gap is via the gender segregation in fields of study itself (the endowment effect), rather than through heterogeneous returns for the same credential (the coefficient effect). The increasing gender segregation in fields of study that favors men, which contrasts sharply with the decreasing trend of gender inequality in education access and labor market discrimination, indicates a new pattern of gender inequality generating process. The findings speak to the debates about the relationship between industrialization and gender inequality: we conclude that industrialization process helps to reduce gender inequality in some aspects but fails in others, especially when gender difference is not caused by explicit discrimination. Our work also contributes to explain the stalled growth of females' income relative to males', from the education domain.

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Research Questions and Underlying Theories

It is nowadays a worldwide phenomenon that gender gaps are shifting from favoring men towards favoring women on some indicators of educational attaiment. Despite its ingrained "son preference" culture as a byproduct of Confucianism, China is now among those countries where women outperform men in tertiary education attainment rate. Figure 1 shows the number and percentage of females currently enrolled in higher education in China during the period of 1957 to 2015. From year 2009, the percentage of females enrolled in tertiary education began to surpass that of males.

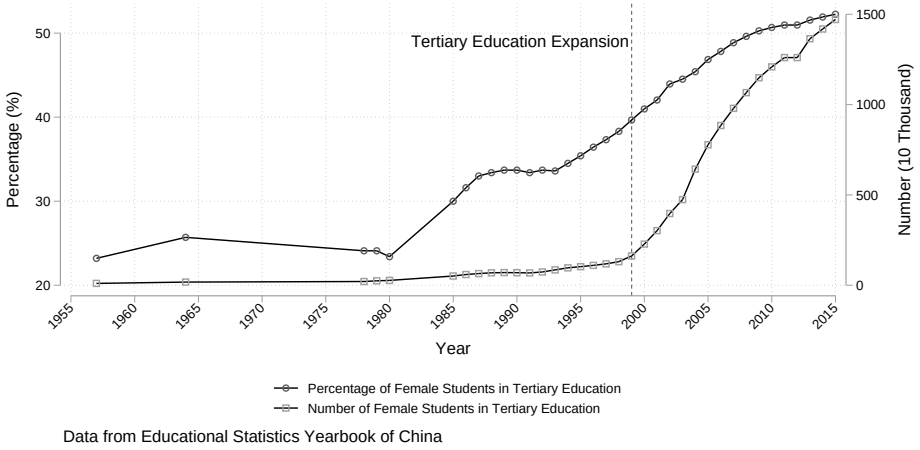

Figure 1: Number and Percentage of Female in Higher Education:1957-2015

The trend of decreasing gender inequality in education access is in line with some theories which believe that the industrialization process would enhance gender equity. However, as scholars are digging into the horizontal stratification within tertiary education, it turns out that gender segregation in fields of study gets even severer with the deepening industrialization and spreading gender-egalitarian social norms. Moreover, previous literature has documented that the growth of females' income relative to males' is reaching a ceiling,

although the rising women's share of tertiary education and shrinking labor market discrimination are observed in the meantime. Explanations for the seemingly paradoxical results could also be provided by industrialization and changing gender norms: while industrialization's demand for manpower brought more females into labor market and educational institutions, the booming service sector placed thoses females into certain "feminized" occupations and thus Non-STEM majors; while gender-egalitarian values undermines the basis for discrimination towards the female, it also supports self-expression which is leading girls into "feminized" careers.

To portrait a relatively comprehensive picture of the changing gender inequality in China via examining the gendered choice of majors and its consequences, we would like to delve into questions below:

1. Firstly, we would explore the level of gender segregation in fields of study, especially the segregation between STEM/Non-STEM majors. We will also track the changes of segregation level across different cohorts and try to find out the sources of those changes.

2. Secondly, we will estimate the economic leverage of holding a degree of STEM majors instead of Non-STEM majors. Moreover, we'd inspect whether the returns to a STEM degree are significantly different for males and females, or, to put it another way, whether there's an income gap between males and females even if they hold the same kind of degree.

3. Thirdly, we would examine the role of fields of study in explaining gender wage gap. We would also detect the mechanism by decomposing the total effect into two parts: a composition effect–the gender wage gap due to the different STEM degree attainment rates by gender; and a coefficient effect–the gap due to heterogeneous returns to a STEM degree.

The significance of our research lies in several ways:

1. Firstly, we attempt to portrait a relatively comprehensive picture of the changing gender differences in tertiary education sphere. The gender equity in tertiary education access tend to come at the same time with increasing gender segregation within higher education institutions, as is suggested by previous literature investigating some developed countries. Researches conducted in China have confirmed the current female advantage in higher education access, but further inqueries need to be placed onto the changing gender segregation pattern in fields of study.

2. Secondly, we dig into the unexplained gender wage gap by taking into consideration the role of horizontal stratification in tertiary education. A branch of literature tends to arbitrarily categorize the part of gender income gap which couldn't be explained by observable variables into statistical disctimination based on gender. This approach would be misleading, when an unobservable cause of gender wage gap is not discriminating in nature. Gender segregation in tertiary education majors might be the case, since its formation is not a pure result of discrimination but would lead to gender inequality in economic outcomes.

3. Thirdly, our work contributes to the debate about the relationship between mordenization and gender inequality. We are prone to believe that the mordenization process helps to reduce gender inequality in some aspects but fails in others, especially when gender difference is not caused by explicit discrimination.

Data and Methods

The main dataset we employ is the national representative dataset–China Family Panel Survey (CFPS) 2010. The survey collected rich information about respondents' demographic features, cognitive ability measurements for both the mathematical ability and language ability, family socioeconomic background, educational attainment including both years of education received, university types and our key independent variable–the tertiary education major, and labor market achievements. The final sample size for our main analysis is 1,647, including respondents who were 16-60 years old, with a tertiary education degree or above, with positive monthly earnings, and with a non-agricultural occupation when the survey was conducted.

We answer our research questions step by step. Firstly, we calculate Duncan segregation index both for the whole sample and for different cohorts. We also decompose the changing segregation level into one part due to changes in the major mix and changes due to shifts in sex composition within majors. Logit model is adopted to estimate the influence of gender on STEM degree attainment likelihood, after controlling for all observable confounders. Secondly, ordinary least square (OLS) regression is employed to calculate the returns of STEM major and to test whether the returns are heterogeneous between genders, and propensity score matching (PSM) is used to reduce possible selection bias and to help establish a clearer causal inference. Finally, a detailed decomposition is employed to separate out the endowment effect and coefficient effect of STEM major degree on gender wage gap.

Preliminary Results

Gender Segregation in Fields of Study

Table 1 displays the Duncan segregation index, the change of the index by cohort, and the origin of the changes. The Duncan Segregation Index is 18.8 for the whole sample. This index increases for younger cohorts; for birth cohort 1980-1990, the index reaches 28.1. Then the change between different cohorts is decomposed into different origions: MIX stands for changes due to shifts in the major mix, COMP stands for changes due to shifts in sex composition within majors, and INTER stands for changes due to the interaction of the two factors. For cohort born in 1970s, the changes due to shifts in sex composition within major contribute the most to the increase. While for the 1980s birth cohort who enter into tertiary education after its expansion, the changes due to shifts in the major mix contribute a larger part.

Table 1: Change in Gender Segragation among Fields of Study

Duncan Segregation Index			Origin of the Change			
			MIX	COMP	INTER	Total
C1: 1949-1970	10.8					
C2: 1971-1980	20.0	C1-C2	+2.4	+5.6	+1.1	+9.2
C3: 1981-1990	28.1	C2-C3	+4.3	+3.7	+0.1	+8.1
Total	18.8					

We then employ logit models to estimate the effect of gender on the odds of choosing a STEM major against a Non-STEM major. The ability, demographic features, and social origin are correlated with gender and at the same time influence the chances of getting a STEM degree, so we include those confounders into the logit model to achieve the net effect of gender. Table 2 displays the logit model results for STEM degree attaiment; the

exponentiated coefficients and the absolute z scores are reported. In model (1) the coefficient for $Male$ indicates that the odds of getting a STEM major to getting a Non-STEM major for male is 2.177 times larger than that for female after controlling for demographic variables and social origin variables, and the effect is significant. Model (2) further controls for the math and language abilities: the math ability has positive and significant influence on STEM degree attainment, but the odds of getting a STEM major to getting a Non-STEM major for male is still about 2 times larger than that for female. What's more, model (3) indicates that the influence of gender on STEM degree attainment increases by cohort, which is in line with the findings using Duncan segregation index.

Table 2: Logit Model for STEM Degree Attainment

	(1)	(2)	(3)
Male	3.177^{***}	3.088^{***}	2.233^{**}
	(9.146)	(8.716)	(2.953)
Std Mathematical Abiity		1.506^{***}	1.511^{***}
		(7.164)	(7.189)
Std Language Ability		1.041	1.047
		(0.630)	(0.726)
1971-1980	1.457^{*}	1.374^{*}	1.194
	(2.464)	(2.029)	(0.598)
1981-1990	2.574^{***}	2.311^{***}	1.541
	(6.238)	(5.412)	(1.552)
1971-1980 $\times$ Male			1.177
			(0.469)
1981-1990 $\times$ Male			1.815^{+}
			(1.787)
Demographic Variables	Y	Y	Y
Social Origin Variables	Y	Y	Y
Number of observations	1,647	1,647	1,647

Exponentiated coefficients; Absolute z statistics in parentheses.
$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.005$, *** $p < 0.001$.

Economic Return to STEM Degrees, and How It Varies by Gender

Table 3 shows the results of OLS regressions of individual's logged yearly labor income on STEM degree and other covariates. Model (1) indicates that males earn 22.6% $[(e^{0.204} - 1) * 100\%]$ more than females. The coefficients of STEM degree in model (1) and model (2) show that the economic return to STEM degree is positive and significant, and individuals with a STEM degree earn 13.4% $[(e^{0.126} - 1) * 100\%]$ more than individuals with a Non-STEM degree even after controlling for the ability measurements. However, the economic return to STEM degree is not significantly different between genders: the coefficient of the interaction term of gender and STEM degree attainment of model (3) is not significant.

Table 3: OLS Estimates for STEM Degree Return

	Total			Male	Female
	(1)	(2)	(3)	(4)	(5)
Male	0.204^{***}	0.207^{***}	0.203^{***}		
	(0.040)	(0.040)	(0.045)		
STEM Degree	0.138^{**}	0.126^{*}	0.113	0.123^{*}	0.134^{+}
	(0.044)	(0.045)	(0.076)	(0.055)	(0.079)
STEM Degree × Male			0.020		
			(0.093)		
Ability Measures		Y	Y	Y	Y
Education Years & Quality	Y	Y	Y	Y	Y
Demographic Variables	Y	Y	Y	Y	Y
Social Origin Variables	Y	Y	Y	Y	Y
Labor Market Variables	Y	Y	Y	Y	Y
R Squared	0.279	0.282	0.282	0.266	0.278
Number of observations	1,647	1,647	1,647	907	740

Standard errors in parentheses.

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.005$, *** $p < 0.001$.

We then adopt propensity score matching (PSM) method to kind of infer the causal effect between STEM degree attainment and labor market income. We proceeds in 3 steps, and those steps are repeated for the whole sample, and subsamples by gender seperately:

firstly we calculate propensity score after binary logistic regressions; secondly we match the treatment group with a STEM degree and the control group with a Non-STEM degree based on their propensity scores using one-to-one nearest-neighbor matching with replacement; thirdly we estimate a multivariate OLS regression which further controls the post-treatment labor market variables using the matched sample. The PSM estimation of economic return to STEM degree in table 4 even indicates that the treatment effect of STEM degree attainment for female is even larger than that for male.

Table 4: PSM Estimates for STEM Degree Return

	Total		Male	Female
	(1)	(2)	(3)	(4)
Male	0.278***	0.324***		
	(0.058)	(0.080)		
STEM Degree	0.128*	0.195*	0.123***	0.178***
	(0.052)	(0.096)	(0.037)	(0.038)
STEM Degree × Male		−0.096		
		(0.114)		
Years of Education Received	Y	Y	Y	Y
Labor Market Variables	Y	Y	Y	Y
R Squared	0.291	0.292	0.254	0.287

Standard errors in parentheses.

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.005$, *** $p < 0.001$.

Fields of Study & Gender Wage Gap: A Decomposition

After we estimate the role of gender in determining STEM degree attaiment and the economic returns to STEM degree by gender, we still need to figure out a way to answer the question: which is a more important mechanism for gender wage gap – the gender segregation among majors or the different returns to STEM major by gender. The detailed decomposition method, which decompose the gender wage gap into endowment effect and coeficient effect of a STEM degree, provides a solution. Table 5 shows the endowment effects and coefficient effects of STEM degree attaiment on gender wage gap, using the de-

tailed decomposition with males as reference group. Giving female the same rate of STEM major attainment as male would reduce the gap by 8.98%; while equalizing returns to STEM major attainment is expected to have not much effect to gender wage gap (0.90%). Thus it could be concluded that STEM degree attainment increases the gender wage gap mainly through the gender segregation among majors during the education period rather than through unequal returns to the same degree in the labor market. The decomposition result is consistent with previous logit and regression results.

Table 5: Detailed Decomposition Results with Male as "Standard"

	Coef	Percent
Total Effect		9.87%
Endowments Effect	0.027**	8.98%
	(0.011)	
Coefficients Effect	0.003	0.90%
	(0.016)	

Standard errors in parentheses.
$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.005$, *** $p < 0.001$.

Conclusions

To wrap up, the major preliminary findings are as follow.

1. Gender segregation of majors exist and the segregation level increases for younger cohorts. Males are far more likely to obtain a more lucrative STEM major than a Non-STEM major.

2. The return to STEM major for female is not significantly lower to that for male using OLS regression estimation. Whats more, the results of PSM indicates that the treatment effect of STEM degree attainment for female is even larger than that for male.

3. The gender segregation of majors contributes more to the gender wage gap than the diverted returns to majors by gender. STEM degree attainment increases the gender wage gap mainly through the gender segregation among majors during the education period rather than through unequal returns to the same degree in the labor market.