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Author
Li, Xin

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by

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ABSTRACT OF THE DISSERTATION

College Major Choices in China

by

Xin Li

Doctor of Philosophy in Education

University of California, Los Angeles, 2022

Professor Ozan Jaquette, Chair

Major choice matters for both individuals' welfare and the overall economy. A large body of studies in various countries has documented the determinants of college major choices, such as individual background characteristics, expected earnings and ability sorting, structural barriers in K-12 education, peer and family influences and expectations, and supply-side factors (Kanny et al., 2014; Patnaik et al., 2020). This three-chapter dissertation contributes to the literature on college major choices by providing new evidence on the role of factors from both the investment side (student demand) and the supply side (college major reforms) in the college major choices of students in China.

In the first paper, "Do Women Hold Traditional Gender Role Beliefs More/Less Likely to Choose STEM Majors in China?", I investigate the role of gender role beliefs in female and male students' college major choices. Women continue to be underrepresented in most STEM-related fields in both higher education and the labor market. The study extends the existing literature by

exploring the role of individual gender-related beliefs in college major choices. Using representative college student survey data, I find that female students are substantially underrepresented in most STEM majors. Gender role belief can be one potential underlying psychological factor that explains the gender disparity in STEM major choices. Female students with more traditional gender role beliefs are more likely to choose STEM. The association between the traditional gender role beliefs and STEM major choices for females is predominantly concentrated in the non-advantaged STEM majors and STEM majors at non-selective universities. The pattern exists for students who originate from more advanced household statuses and regions, but not for high-achieving students. Female students entering the STEM domain experienced internalized sexism by assimilating the gendered social norms and endorsing the male privilege in this field.

In the second paper, "The Impacts of College Major Reforms on Student Composition in China," I examine the effects of college major reforms on student composition within college-majors. In the context of the Chinese meta-major reform, this paper provides one of the first empirical evidence on the consequences of a transition from college-major to college-then-major choice mechanism. Using administrative data on college admissions over 18 years, I study the impacts of the staggered adoption of the reform across institutions on student composition. I do not find aggregately statistically significant effects of the meta-major reform on the distribution of ability and demographic characteristics of students by college-majors. The result is robust to using alternative measurements, samples, models, and estimators. However, the aggregate null effects are masked by the heterogeneity across institutions and majors. The impact of increasing admission scores is predominantly concentrated in non-elite institutions and non-advantaged

STEM majors. The reform also alters the student profile in terms of ethnicity and place of origin at the most prestigious institutions.

The third paper - “College-Major Choice to College-then-Major Choice Reform: Experimental Evidence on Student College Major Choice Behavior” - studies students’ responses to various types of information on meta-major reform. One of the most important mechanism design policies in college admissions is for students to choose a college major sequentially (college-then-major choice) or jointly (college-major choice). However, how students behaviorally respond to these policies is unclear. In the context of the Chinese meta-major reforms, the paper provides one of the first experimental evidence on the heterogeneous impacts of a transition from college-major to college-then-major choice on students’ willingness to apply, with a special focus on the role of information. In a randomized informational experiment with a nationwide sample of high school graduates, the results show that providing information on the benefits of a meta-major significantly increased students’ willingness to apply; however, information about specific majors and assignment mechanisms has insignificant impacts. The information mostly affects the preference of students who come from disadvantaged backgrounds, lack accurate information or clear major preferences, or are risk-loving.

The dissertation of Xin Li is approved.

Chad J. Hazlett

Minjeong Jeon

Lucrecia Santibañez

Ozan Jaquette, Committee Chair

University of California, Los Angeles

2022

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VITA

Education

2015	B.A. in Economics
	Beijing Normal University, Beijing, China.
2018	M.A. in Economics of Education
	Peking University, Beijing, China.

Publications

Ding, Y., Li, W., Li, X., Wu, Y., Yang, J., & Ye, X. (2021). Heterogeneous Major Preferences for Extrinsic Incentives: The Effects of Wage Information on the Gender Gap in STEM Major Choice. *Research in Higher Education*, 1-33. (Equal authorship)

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Selected Presentations

Li, X., Ma, L. P., & Ye, X. Y. (2022, April). College-Major Choice to College-then-Major Choice: Experimental Evidence from Chinese College Admissions Reforms. *The 2022 Annual Meeting of the American Educational Research Association* (*AERA).* (virtual)

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Ding, Y. Q., Li, W., Li, X., Wu, Y. D., Yang, J., & Ye, X. Y. (2020, March) Missing Ladies in Engineering: The Effects of Wage Information on the Gender Gap in STEM Major Choice. The *45th Annual Conference of the Association of Education Finance and Policy (AEFP)*. (virtual)

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Yang, P., & Li, X. (2017, August). Individual Effect of Professional Programs in China: An Institutional Perspective. *The Annual Conference of the Consortium of Higher Education Research (CHER), Jyväskylä, Finland.*

Li, X., & Yue, C. J. (2017, March). Gender and Trans-Provincial Migration: Evidence from College Graduates in China. *The 61st Annual Meeting of the Comparative and International Education Society (CIES), Atlanta, Georgia, USA.*

Chapter 1 Introduction

College Major matters! With increasing educational attainment and work specialization, the focus of research has shifted from the decision to college enrollment to the type of education, such as different college majors. College major choice is directly related to one's labor market performance and welfare (Patnaik et al., 2020). Beyond the individual level, major choice also affects the skill composition in the workforce and has been brought to the forefront of the policy agenda in many countries (Altonji et al., 2016). A large body of studies in various countries has documented the determinants of college major choices, such as individual background characteristics, expected earnings and ability sorting, subjective expectations, peer and family influences and expectations, structural factors in K-12 education, college and major factors (Kanny et al., 2014; Patnaik et al., 2020). The dissertation contributes to this strand of literature by providing new empirical evidence on both investment-side and supply-side determinants of college major choices. On the investment side, I consider how students' beliefs relate to their major choices, with a special focus on the association between gender role beliefs and gender differences in choices. On the supply side, I consider the higher education institutions' organization and regulations of college majors, and how these would affect students' preferences and choices.

China's college admission system was established in 1978, which is the largest centralized student-college matching market in the world. From 1977 to 2018, the number of examination takers has risen steadily from 5.7 million to 9.75 million, and the college admission rate has also increased from about 4.74% to about 81.13%[1]. The centralized admission system allocates applicants to majors and colleges only considering their declared preferences and their

[1] Data source: https://Gaokao.koolearn.com/20190226/1208064.html. Retrieved 2020-06-17.

academic performance, i.e., solely the test scores in *Gaokao*, not depending on high school GPA. Generally, students are required to choose a college-major pair jointly when they submit their college applications. This college-major-specific mechanism makes students have to choose majors based on their precollege knowledge and interests, which potentially lead to student-major mismatch problems (Bordon & Fu, 2015). Additionally, inequality in educational attainment still exists across students with different characteristics and from different backgrounds. For example, although women have overtaken men in higher education access since 2011, the gender gap in STEM fields has continued to increase in recent years, and women remain in a disadvantaged position in terms of occupational opportunities and earnings in STEM. Moreover, students from poor regions and with low income are more likely to be faced with the barriers of insufficient guidance and information, especially when new college policies or major options are provided.

The dissertation is motivated by the fundamental problems in college major choice in China and the interdisciplinary area of research on college major choice from the following two directions.

First, the gender gap in STEM persists over time and remains an important policy problem in higher education (Kugler et al., 2017; Ganley et al., 2018). Despite the increasing share of women in college enrollment, women continue to be underrepresented in most STEM-related fields in both higher education and the labor market in many western countries (e.g., Kanny, et al., 2014, McNally, 2020). Based on nationally representative data, the problem of the underrepresentation of women in STEM fields also exists in China (see more details in Section 2.2.2). Understanding the critical determinants and the underlying mechanisms of gender gaps in college major choices would be of great value in overcoming the challenges and barriers women face and helping students to make better choices. Various determinants of college major choices have been documented in previous literature. Amongst, subjective preferences and beliefs have been increasingly identified as one of the overarching explanations for gender gaps in major choices (Kanny et al., 2014; Patnaik et al., 2020). STEM-related fields of study and careers are usually considered male domains excluding women (Nosek et al., 2009). Students' aspirations to enter STEM could be straightly related to their gender role concepts and the gender-related perceptions of the field (Dicke et al., 2019). However, the empirical manifestation of the relationship between students' gender role beliefs and STEM major choice is still unclear. The investigation of the relationship would be important for us to learn how gender socialization could impact women's education and career path.

Second, various supply-side policies in higher education, such as tuition, admissions criteria, and targeted financial aid, have been used to alter the composition of college majors (Patnaik et al., 2020). One of the most important mechanism design policies in college admissions is to allow students to choose a college major sequentially (college-then-major choice) or jointly (college-major choice). The college-major choice provides students with more specialized training upon college enrollment and helps them confer degrees quickly and efficiently. Alternatively, the college-then-major choice allows students to explore and develop their major-specific interests, with a low switching cost. In China, a reform allowing a subset of universities to switch from the jointly college-major admissions to sequentially college-then-major admissions was recently started. The reform potentially has a large impact on students' educational choices and changes the composition of students across college majors. Recent literature shows that delaying specialization in a college-then-major choice mechanism is conducive in helping students discover their comparative advantage. Furthermore, it increases student-major match quality and student welfare (Bordon & Fu, 2015). However, in the context of major reform in China, students were not given complete information on the setting, benefits, and potential risks associated with the new major policy. Therefore, they faced increased uncertainty after the reform. Which policy is better for a targeted group of students depends on student sorting, which is relevant to students' academic achievement, prior major intent, risk attitudes, application strategy, etc.; however, little is known from the literature about how students would behaviorally respond to different college major choices policies. Students' major intent can be largely affected by what information is available and how options are structured in the reform. Moreover, students' application and admission results may change in response to the reform, and thus the student composition of college majors alter accordingly.

The dissertation includes the following three papers to address the questions about (1) individual beliefs and gender gaps in college major choices, (2) college major reforms and student composition across college-majors; (3) college major reforms and students' preferences for college majors, with a special focus on the role of information.

In the first paper, "Do Women Hold Traditional Gender Role Beliefs More/Less Likely to Choose STEM Majors in China?" I investigate the role of gender role beliefs in female and male students' college major choices. The study aims to extend the discussion of subjective beliefs and psychological factors as the dominant explanations for the gender gap in major choices (Kanny et al., 2014; Patnaik et al., 2020). Using representative college student survey data, I first estimate the gender gap in STEM major choices, and then explore the major choice patterns of female and male students in terms of how one's gender role beliefs relate to the choices and how the relationship could be different for female and male students. Additionally, I investigate whether the association is consistent when different samples of students, alternative measurements, and models are used. Furthermore, I analyze the heterogeneity of the association by various major features and institution types, as well as different student characteristics. Finally, discussions on male privilege and internalized sexism in STEM are provided. Knowledge of the mechanism of the gender gap in major choice has important implications for individual major choice and for public policy reforms to improve the student-major match, occupational opportunities, and long-term outcomes worldwide.

The second paper, “The Impacts of College Major Reforms on Student Composition in China” and the third paper, “College-Major Choice to College-then-Major Choice Reform: Experimental Evidence on Student College Major Choice Behavior” study the transition from the jointly college-major choice to the sequentially college-then-major choice in China, i.e., the meta-major reform. Colleges undertaking the reform cluster relevant majors to form a larger meta-major; for example, an engineering meta-major includes all engineering-related majors. Students could be admitted to a meta-major first at the entrance of college, and then decide their final major within the scope of the meta-major after one or two years of education under the general field of study. In the second paper, I examine the effects of college major reforms on student composition within college-majors. Using administrative data on college admissions over 18 years, I assess how the distribution of student ability and demographic characteristics would change after the implementation of the meta-major reform over time. Furthermore, variations across different institutions and major categories are also investigated. Finally, I discuss the meta-major reform as a recruiting strategy for universities and its implications for students from different backgrounds.

The third paper studies student’s responses to various types of information on meta-major reform. We designed a randomized informational experiment for high school graduates to see how students' willingness to apply can be changed by different types of information on the meta-major reform, including information about specific majors, benefits, and assignment mechanisms of the meta-major. Also, the effects could be different for students from diverse backgrounds, with different prior knowledge, major preferences, and risk attitude. Building on the supplementary qualitative evidence from one of the largest Chinese online discussion boards and focus group interviews, we provide interpretations for the experimental results. The paper contributes one of the first pieces of empirical evidence on the ongoing worldwide policy reforms alternating between college-major and college-then-major choice. The findings provide pivotal implications for higher-education institutions reforming college majors to attract more talented students, high school and college counselors providing guidance and assistance to high-school graduates, and individual students making one of the most important decisions of their lives.

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Chapter 2 Do Women Hold Traditional Gender Role Beliefs More/Less Likely to Choose STEM Majors in China?

Abstract

Women continue to be underrepresented in most STEM-related fields in both higher education and the labor market. The study extends the existing literature by exploring the role of individual gender-related beliefs in college major choices. Using representative college student survey data, I find that female students are substantially underrepresented in most STEM majors. Gender role belief can be one potential underlying psychological factor that explains the gender disparity in STEM major choices. Female students with more traditional gender role beliefs are more likely to choose STEM. The association between the traditional gender role beliefs and STEM major choices for females is predominantly concentrated in the non-advantaged STEM majors and STEM majors at non-selective universities. The pattern exists for students who originate from more advanced household statuses and regions, but not for high-achieving students. Female students entering the STEM domain experienced internalized sexism by assimilating the gendered social norms and endorsing the male privilege in this field.

Keywords: College major choice, Gender gap, Gender role beliefs

Introduction

Major choice matters for both individuals' welfare and the overall economy. College major choice is directly related to labor market performance, especially for fields requiring occupational-specific skills (Patnaik et al., 2020).[2] Significant variation exists when considering earnings by college major, as the discipline in which students earn their degrees may account for 25-35 percent of the earnings differences (Arcidiacono, 2004; Altonji et al., 2012). Even after controlling for selection and ability differences, majors such as business and science, technology, engineering and mathematics (STEM) have large earnings premiums (Arcidiacono, 2004; Altonji et al., 2012). Beyond the individual level, major choice also affects the skill composition in the workforce and has been brought to the forefront of the policy agenda in many countries (Altonji et al., 2016).

The gender gap in STEM persists over time and remains an important policy problem in higher education (Kugler et al., 2017; Ganley et al., 2018). The earning inequality across gender and other demographic groups may be explained by the composition of college major choices (Gemici & Wiswall, 2014; Patnaik et al., 2020). Despite the increasing share of women in college enrollment where women have outnumbered men for decades, women continue to be underrepresented in most STEM-related fields in both higher education and the labor market (Kanny, et al., 2014)[3]. The gender gaps in STEM majors and in subsequent average wages earned after completing a bachelor's degree persist (Kugler et al., 2017). Numerous government and other policy initiatives have been designed to increase the number of traditionally

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[2] The real relationship between education and career is complicated. The connections between some STEM degrees and labor market outcomes are obvious, while the connection is more nebulous for other degrees. A related report: https://economicmodeling.com/degrees-at-work/.

[3] Women aren't underrepresented in all STEM fields, for example, women outnumber men in the bachelor's degrees in biological and biomedical sciences, according to data released in 2016 by the National Center for Education Statistics (NCES).

underrepresented students majoring in STEM (Melguizo & Wolniak, 2012; Soldner et al., 2012). However, the efforts to expand women's disparate participation in STEM are not working as well as intended (Kugler et al., 2017). For example, initiatives designed to get women interested in STEM fields and overcome the masculine STEM stereotype may have the unintended effect of signaling to women an inherent lack of fit (Kugler et al., 2017). Therefore, work that makes further progress on designing appropriate behavior interventions to overcome the challenges and barriers women face in major choice and nudge students into matched majors will be valuable. Identifying the critical determinants of major choice and understanding the underlying behavioral mechanisms will be the first crucial step in informing intervention design in research, practice, and policy (Damgaard & Nielsen, 2018).

The previous literature suggests that instead of gender differences in individual college preparedness, individual preferences and psychological factors remain the main explanation for gender gaps in major choices (Kanny et al., 2014; Patnaik et al., 2020). Further progress on unpacking the black box of tastes is needed (Patnaik et al., 2020). Psychological factors, such as the feelings of self-confidence, competence, and ability, are key factors in explaining students' educational choices and performance in specific academic domains (Wang, 2013; Kanny et al., 2014). STEM-related fields of study and careers are usually considered male domains excluding women (Nosek et al., 2009). Students' aspirations to enter STEM could be straightly related to their gender role concepts and the gender-related perceptions of the field (Dicke et al., 2019). However, the empirical manifestation of the relationship between students' gender role beliefs and STEM major choice is still unclear. Moreover, there is a dearth of credible evidence on the gender gap in college majors within the Chinese centralized college admission system (Zeng et al., 2014). The study extends the existing literature by exploring the role of individual beliefs in college major choices. This study aims to answer the following research question:

1. To what extent do students' individual gender role beliefs relate to their probabilities of choosing STEM majors for females and males?

Using representative college student survey data - Beijing College Students Panel Survey (BCSPS), the study contributes to the literature by examining how individual gender role beliefs influence students' college major choices. Knowledge of the mechanism of the gender gap in major choice has important implications for individual major choice and for public policy reforms to improve the student-major match, occupational opportunities, and long-term outcomes worldwide. The study extends the discussion of individual values and psychological factors as the dominant explanations for the gender gap in major choices (Kanny et al., 2014; Patnaik et al., 2020). Although the college admissions process might differ from other countries, the studies on major choice mechanisms in the Chinese context can be highly relevant to other higher education contexts.

Background

In this section, I will begin by providing background information on the general college admissions system in China, including *Gaokao*, college application and admission. Next, I describe the broad patterns of gender disparities in education access, major choice, employment, and earnings.

The General College Admissions System in China

China's college admission system was established in 1978, which is the largest centralized student-college matching market in the world. As the prerequisite for entering almost all undergraduate institutions[4], *Gaokao* is a standardized academic test usually held on June 7 and 8 annually[5]. From 1977 to 2018, the number of examination takers has risen steadily from 5.7 million to 9.75 million, and the college admission rate has also increased from about 4.74% to about 81.13%[6]. In most provinces, the test includes three mandatory subjects - Chinese, mathematics, foreign language, and three other subjects from one of two independent tracks - science[7] or humanities[8], which is also known as "3+X" system[9]. Students choose one track in grade 11, take the examination in the last year (grade 12) of senior high school, and participate in the college admission process in their residence province.

The centralized admission system allocates applicants to majors and colleges only considering their declared preferences and their academic performance, i.e., solely the test scores in *Gaokao*, not depending on high school GPA. The preference reporting and admission mechanism is a two-way selection procedure between students and colleges, where students are eager to enter the most desirable colleges, and colleges are willing to recruit the best students - in the Chinese context - students with the highest *Gaokao* score. Students apply for different tiers of higher education institutions, including key universities, regular provincial and local four-year

[4] A small proportion of students are exempted from the examination due to exceptional or special talent.
[5] Due to the coronavirus pandemic, Gaokao in 2020 has been postponed to July 7 and 8.
[6] Data source: https://Gaokao.koolearn.com/20190226/1208064.html. Retrieved 2020-06-17.
[7] Science track: in addition to Chinese, mathematics and foreign language (mostly English), students also take physics, chemistry and biology.
[8] Humanities track: in addition to Chinese, mathematics and foreign language (mostly English), students also take history, geography and political science.
[9] The subjects included might be different for some provinces. For example, Jiangsu reformed to a "3+1+2" system in 2019. In addition to the three compulsory subjects, students choose one subject from physics and history, and two subjects from political science, geography, chemistry and biology.

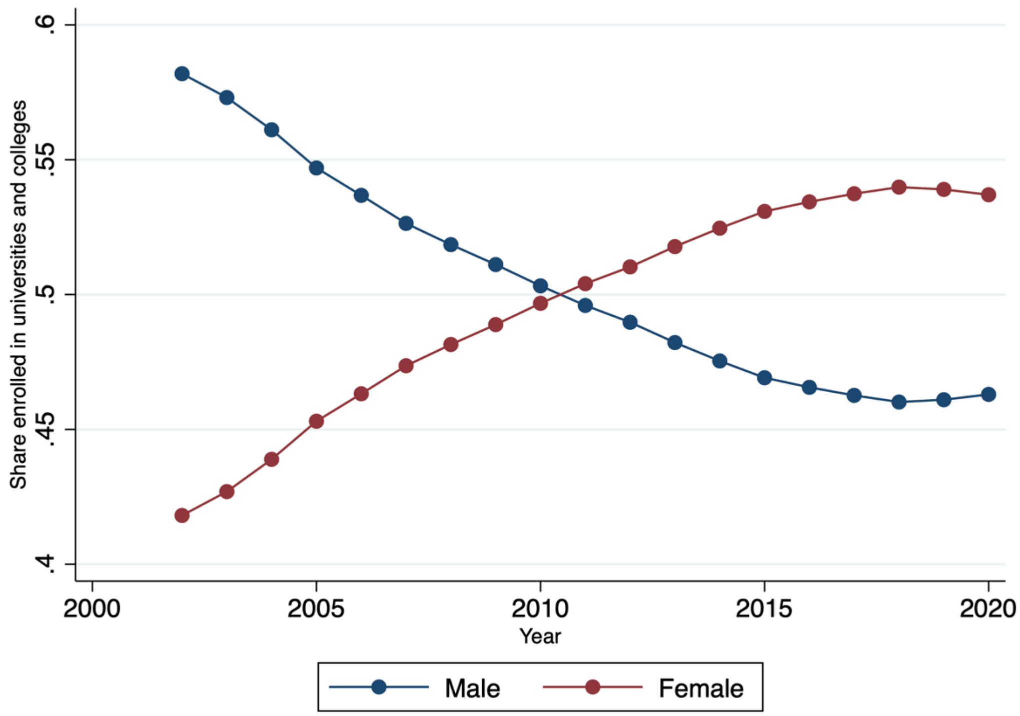
colleges, and tertiary vocational colleges. Unlike countries such as the United States, students usually choose majors at the time of application. Normally, students are usually allowed to apply for four to six different colleges and three to five majors within each college. The examination and admission for each track are conducted separately by each provincial-level administrative division. The *Gaokao* scores are only comparable within a given province-year-track, and the admission cut-offs are announced for each track and tier by each province based on the distribution of scores and the quotas assigned.

Gender Disparities in Education and Occupation in China

In this section, I will describe the broad patterns of gender disparities in higher education access, college major choice, employment, and earnings in China. The description provides some of the background and motivation for this study.

Access to Higher Education. China has seen a significant increase in education access over the last two decades. Figure 2.1 reports the trend in the fraction of females and males enrolling in universities and colleges across the country based on the Education Statistics Data from the Ministry of Education of the People's Republic of China from 2002 to 2020. There is a steady increase in the fraction of women. Women have overtaken men since 2011, and there has been a seven percentage points gap in the enrollment between women (53%) and men (46%) in the most recent years.

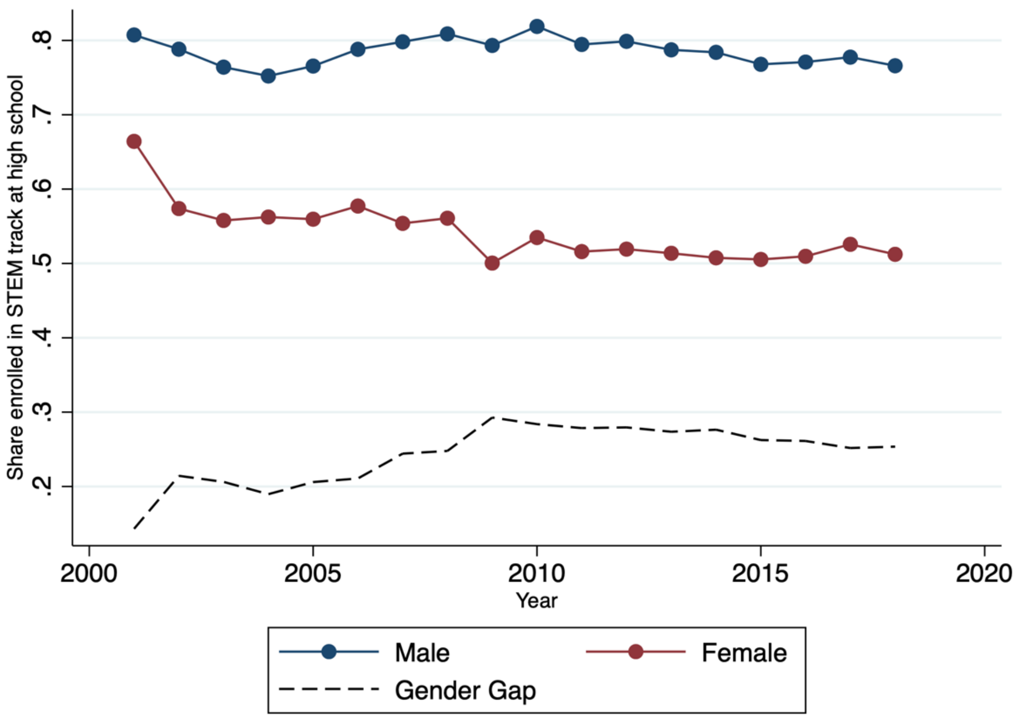
Figure 2.1 Trends in Access to Higher Education by Gender (2002-2020)



Source. Ministry of Education of the People's Republic of China

Access to College Majors. Looking beyond college access, I use administrative data of high school graduates in a Chinese province to construct the fraction of high school track (science/humanities) and college majors by gender. Figure 2.2 plots the trends in high school track for females and males from 2000 to 2018. We can see that there are substantial gaps in the fraction of female and male students enrolling in the science track over time. Males are about 26 percentage points more likely to choose a science track in high school in recent years.

Figure 2.2 Trends in Enrollment in Science Track at High Schools by Gender (2001-2018)

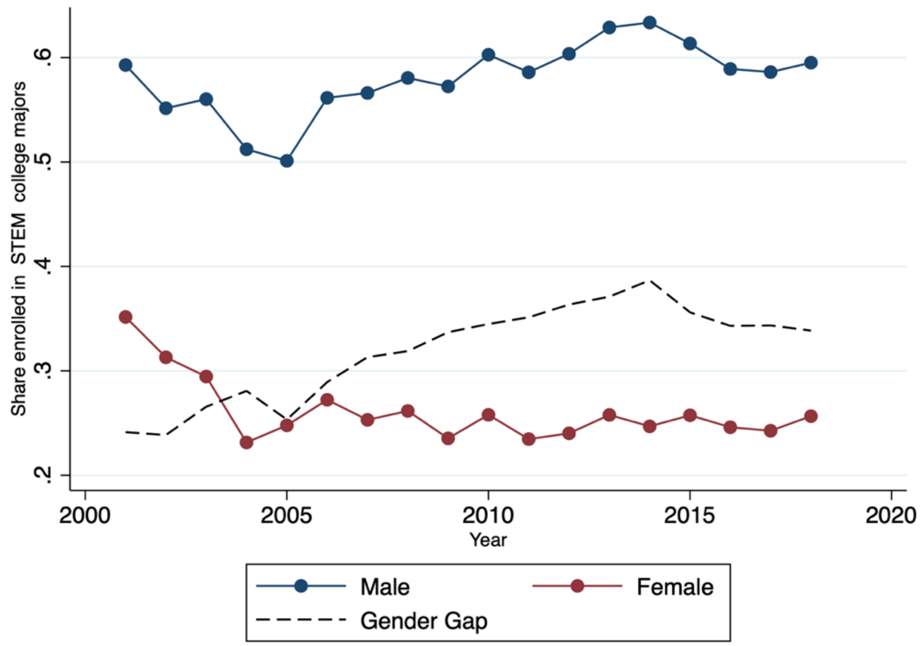


Source. Administrative data of high school graduates in Ningxia Province

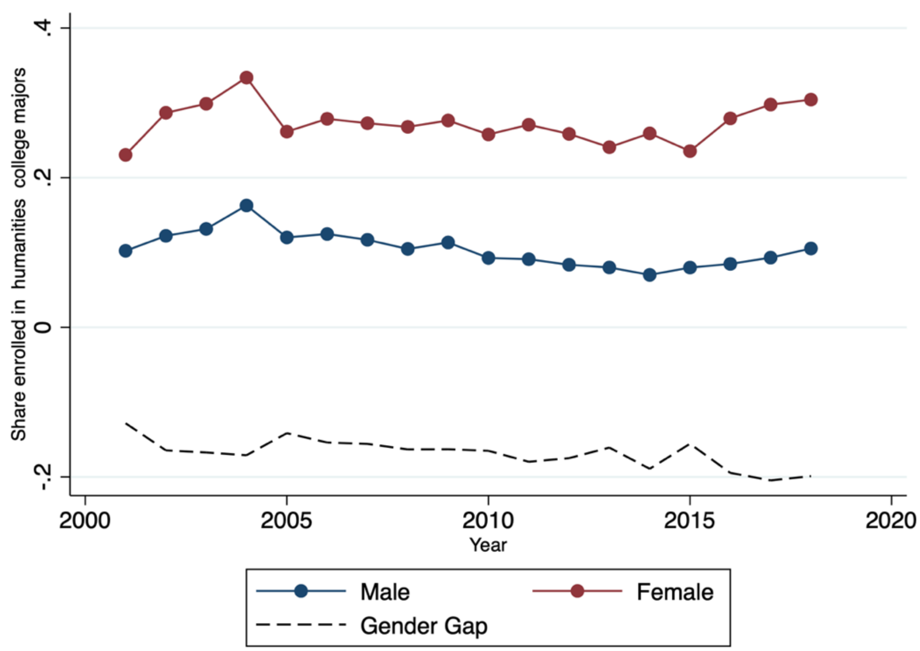
Next, Figure 2.3 plots the trends in college majors for female and male students getting admitted to universities or colleges from 2000 to 2018. I group college/undergraduate majors into three broad categories: (i) STEM, (ii) Humanities, Law, and Education, and (iii) Economics, Business, and Management. The most sizable gender gap in college major enrollment is in STEM (30 percentage points). The gap increases stably from 2005 to 2014. The gender gap in STEM is larger in higher education compared to secondary education as more females leave STEM when making college choices. There are more women in humanities and economics-related majors. And the female and male trends are almost parallel in these majors.

Figure 2.3 Trends in Access to College Majors by Gender (2001-2018)

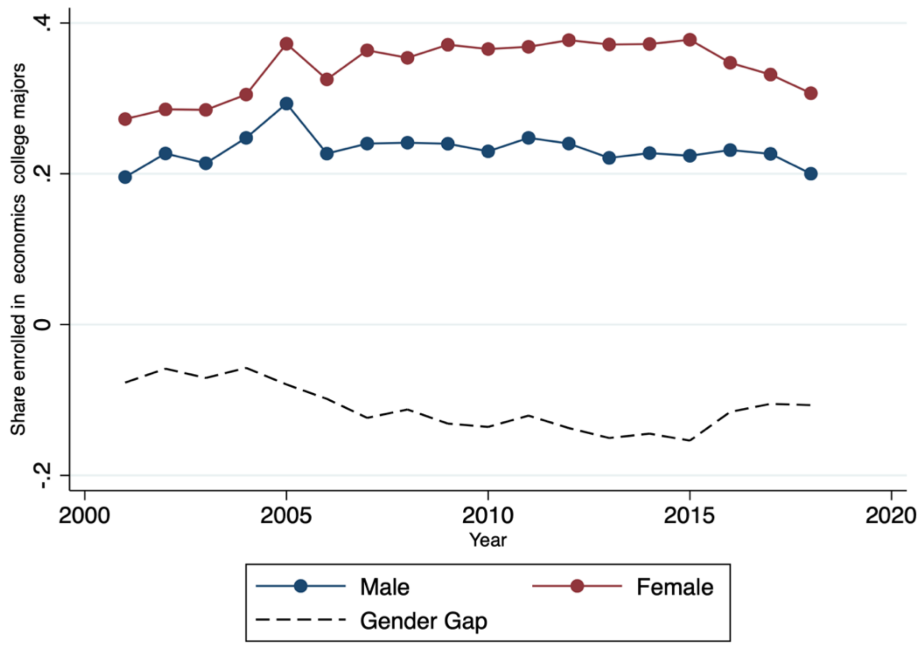
A. STEM



B. Humanities, Law, and Education



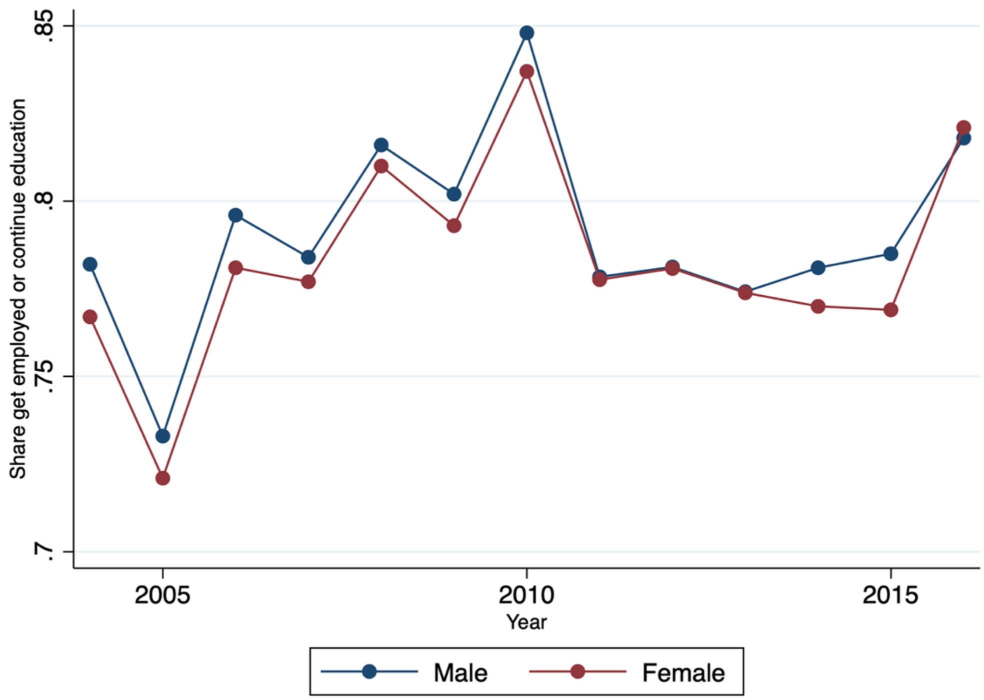
C. Economics, Business, and Management



Source. Administrative data of high school graduates in Ningxia Province

Employment and Earnings by College Majors. Lastly, I examine the patterns in employment and earnings by undergraduate majors and gender. Figure 2.4 plots the fraction of female and male college graduates who get employed or continue with graduate education from 2004 to 2016 using population data from the Ministry of Education of the People's Republic of China. We see that females slightly lag behind males in employment/graduation education in all years but 2016.

Figure 2.4 Trends in Employment / Continuing Education of Undergraduate Graduates by Gender (2004-2016)



Source. Ministry of Education of the People's Republic of China

Next, I use national survey data on college graduates in 2015 to describe more detailed employment status across gender. Table 2.1 reports the employment rate, starting salary, major-career match, and job satisfaction by college major and gender. The differences in employment rate and starting salary are the largest in STEM, that the employment rate of males is 7.7 percent higher than females, and males earn 1117 yuan (22.8%, about $175) more per month. Notably, females in STEM have higher levels of major-career match[10] than males. The levels of job

[10] Survey participants were asked to report whether they think their careers match their college major. It is a four-point scale and the results are transferred to 0-1.

satisfaction[11] are the same for females and males in STEM, while females in the other two major categories report lower satisfaction than males.

[11] Survey participants were asked to report how they are satisfied with their job. It is a five-point scale and the results are standardized to mean 0 and standard deviation 1.

Table 2.1 Employment Status by Major and Gender

Major category	Gender	Employment rate	Starting salary (Yuan)	Major-career match	Job satisfaction
STEM	Male	39.10%	4880.58	0.42	0.50
	Female	31.40%	3763.57	0.44	0.50
	Gap	7.70%	1117.01	-0.02	0.00
Humanities/ Law/ Education	Male	26.65%	4494.09	0.38	0.56
	Female	23.87%	3894.08	0.43	0.51
	Gap	2.78%	600.01	-0.04	0.05
Economics/ Management	Male	38.13%	4679.28	0.42	0.55
	Female	38.94%	3753.83	0.42	0.51
	Gap	-0.82%	925.45	0.00	0.04

Source. 2015 National Survey of Employment Status of Graduate Students (NSESGS), Peking University.

The relative disadvantages in access, employment, and earnings, and a slightly better major-career match and similar job satisfaction for women in STEM provide the key rationale for studying the gender gap in college major choice.

Literature Review

A large body of studies in various countries[12] has documented the determinants of college major choices, such as individual background characteristics, expected earnings and ability sorting, structural barriers in K-12 education, psychological factors, values, and preferences, peer and family influences and expectations, perceptions of STEM fields, supply-side factors (Kanny et al., 2014; Patnaik et al., 2020). And a variety of factors related to the gender disparities in STEM participation have also been investigated, such as the gendered beliefs and attitudes about the responsibilities and roles of women and men, as well as the values of various fields of study and careers (Dicke et al., 2019).

According to the ecological system theory (Bronfenbrenner, 1977) and expectancy-value theory (Eccles, 1983), the macro system, i.e., the social and cultural context, exerts important influences onto one's beliefs through their socialization. The beliefs may vary across nations or cultures depending on the macro system and the values and customs that characterize a given social group (Ertl et al., 2017). Family is one important context where beliefs can be transmitted by communication and support occurring on a daily and lived conditions within family life (Ertl et al., 2017). The social and cultural values and beliefs will be internalized by individuals, and

[12] Both countries with centralized admissions systems, that allocates applicants to majors and colleges only considering their declared preferences and their academic performance, such as Chile, Croatia, Sweden, and also countries, in which college is free to set their own admissions criteria, like the United States.

further impact their educational and occupational aspirations, choices, and behaviors (Eccles, 2015).

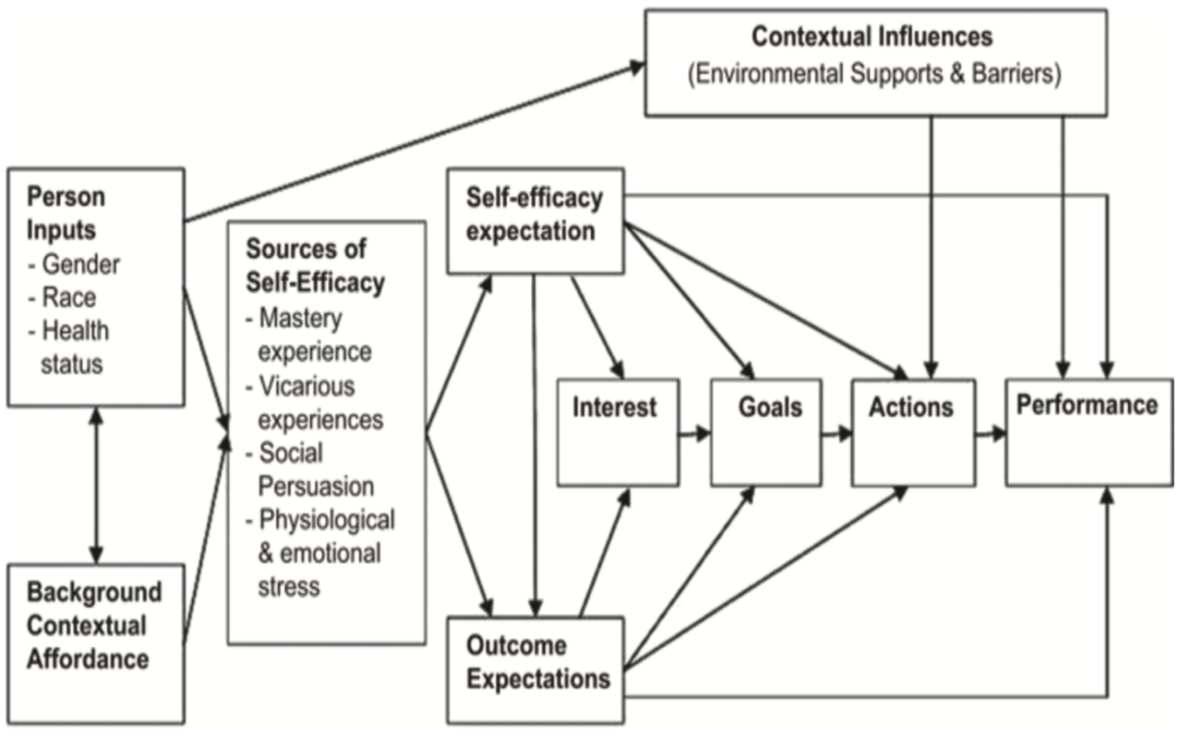
One of the most important beliefs, gender role, is the attitudes and behaviors that are deemed appropriate and desirable for people of a given gender (Eccles, 1983). Traditionally, males are considered the breadwinner and inclined toward male-dominated areas, while women as the caretaker and take more responsibility in the family. In China, the contemporary gender concept is largely inherited and developed from the traditional thoughts of Confucian and Daoist, which emphasize the yang's (male) dominant and yin's (female) subordinate positions, and the complementary relationship between them (Shen & D'Ambrosio, 2014).

Previous research shows that females with traditional gender role beliefs are associated with worse academic performance, lower higher education attainment, fewer working hours and lower income, and a lower probability of persisting in male-dominated occupations, like STEM (Scott, 2004; Corrigall & Konrad, 2007; Frome et al. 2007; Buchmann et al., 2008; Dicke et al., 2019). However, there is a lack of studies empirically investigating the association between gender role beliefs and STEM major choices at college. Moreover, more work is needed to characterize the choice patterns across different STEM majors, such as various categories and levels of prestige (Dicke et al., 2019). Finally, the gender role and its impacts on individual choices and behaviors vary substantially among cultures and regions. The exploration of the rarely studied patterns of college major choices from the perspective of gender norms in China will extend the existing discussions on the role of psychological factors in gender disparity in educational choices.

Theoretical Framework

The study uses the Social Cognitive Career Theory (SCCT) to understand the mechanisms of college major choice and the role of gender role beliefs. Derived from Bandura's (1986) Social Cognitive Theory, Social Cognitive Career Theory (SCCT) has been widely used to explain women's major and career choices (Lent et al., 1994; Kanny et al., 2014). It is a well-substantiated theory in investigating the role of the person, context, and (non-)cognitive process in career development (Li et al., 2019). In SCCT, personal, contextual, and experiential factors influence three foundational "building blocks" of individual career-based decisions, i.e., self-efficacy, outcome expectations, and personal goals (see Figure 2.5). Academic and career interests, choices, and successes are partly determined by self-efficacy beliefs, outcome expectations, and goals. People are exposed to career-related activities under the context in which they engage and dynamically form a sense of efficacy and expectations in this process. They are more likely to develop interest and choose fields that they feel confident with and expect valued outcomes. On the contrary, interest development and choice-making will be impeded if people lack the opportunity to be exposed to such experiences that can give rise to strong self-efficacy and positive outcome beliefs.

Figure 2.5 Social Cognitive Career Theory (SCCT) Model



Source. Lent et al., 1994; Kanny et al., 2014.

Besides personal performance accomplishments, vicarious experiences (e.g., observing similar others, social models) and social persuasion (e.g., being exposed to reinforcing or hindering social messages) can also affect one's foundational "building blocks" of choices. Gender, as both a personal input and a social construct, operates through the process by influencing the sources of self-efficacy and outcome expectations. As one of those important sources, gender role beliefs could predict the gender disparities in the subsequent educational and occupational choices.

Data and Method

The empirical analysis uses data from a representative, longitudinal college student survey (Beijing College Students Panel Survey, BCSPS), which is administered by the National Survey and Data Center at the Renmin University of China. The data followed the 2006 and 2008 entering cohorts of full-time undergraduate students in five waves from college entry to graduate school enrollment or entry into the labor market. In the sampling process, the registration cards of all full-time undergraduate students from 15 public universities are the sampling frame. Adopting a proportional-to-population strategy, the survey uses colleges as the primary sampling units and fields of study as the secondary sampling units (Hu & Wu, 2019). In the baseline survey, 5,100 students were included in the sample and 4,771 (N=2,298 for the 2006 cohort, N=2,473 for the 2008 cohort) of them completed the survey, with a response rate of 93.55% (Wu, 2017). The data collect rich information on students' demographic characteristics, family background, high school experience, non-cognitive dispositions, application preferences and admission results, thus providing a sufficiently rich conditioning set to explore the potential mechanisms through which attitudes and beliefs shape students' major aspirations and choice. Although the BCSPS is a survey based on higher education institutions located in Beijing, the surveyed universities have considerable variation in quality, selectivity (i.e., different strata of institutions: national elite universities[13], 211-program universities[14], non-211-program universities and local universities), and type (e.g., comprehensive university, poly-tech university), which provide good representativeness of the vast majority of institutions in China.

[13] The elite universities in the sample include Peking university, Tsinghua University, and Renmin University of China.

[14] The 211-program aimed at building world-class Chinese universities in the 21st century. The 211-program was launched in 1995 by the Ministry of Education including 112 colleges and universities.

I use multivariate regressions to estimate to what extent gender role beliefs predict individual STEM major choice and entrance for females and males. Given the dichotomous nature of the dependent variable, logistic regression is used to provide the estimated effects of independent variables on the dependent variable in terms of the log of odds.[15]

$$Logit(STEM_i) = ln\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_1 \cdot Female_i + \beta_2 \cdot GenderRole_i + \beta_3 \cdot Female_i * GenderRole_i + \boldsymbol{X_i \Gamma} + \varepsilon_i \quad (2\text{-}1)$$

The outcome variables **($STEM_i$)** include whether the student is admitted to a STEM major (STEM=1, other=0). The survey asked students to report their final admitted major. The stratification of college majors in China persisted over time. STEM majors are appreciated by the state since the socialist era, when industrialization and national security were attached with great importance (Hao et al. 2011). The benefits of the technical specialties of STEM persisted or were even intensified in the process of China's moving into a market-oriented society (Hu & Wu, 2019). A broad STEM major is composed of majors in the science (including mathematics majors) and engineering (including technology majors) categories, and all majors in other categories are coded as non-STEM majors.[16]

The primary independent variable of the study is gender ($Female_i$), i.e., female (yes=1, no=0) and gender role beliefs ($GenderRole_i$). The gender role belief is measured by a five-point scale from 1 = totally disagree to 5 = strongly agree and includes the following four items: *1) Men are inherently better than women; 2) Men should focus on career, whereas women focus on family; 3) A good marriage is better than a good job; 4) Women should be fired first in an*

[15] All analyses are weighted using the sample weight, and therefore, the results generalize to the population of college students of the 2006 and 2008 cohorts.
[16] Based on the major list posted by the Ministry of Education of China, the undergraduate majors are categorized into the following groups: philosophy, economics, law, education, literature, history, science, engineering, agriculture, medical, management, art, and military.

economic recession. In order to reduce the number of variables and multicollinearity in the regression model, principal component analysis is used to create factors for the gender role scale. The principal factor with a promax rotation is used to specify the factors, and the predicted standardized factor scores will be used in the following analysis. Variables with absolute values of loading at 0.5 or higher are considered valid for inclusion in the factor. To examine whether the associations between gender role beliefs and major choices are different across gender, I include an interaction term between the factor of gender role beliefs with gender in the model.

I control for the family socioeconomic (SES) status in the model by adding a factor generated using the principal component analysis consisting of a series of related family background variables. The survey collects rich information on family background, including parental educational attainment, occupation, political identity, hukou,[17] household income, self-reported family economic and social status, and residential province. In addition to parental education and occupation, political identity is also included in the analysis, because studies have found that the political connection and loyalty influence one's access to various life chances even in the reform era (Hu & Wu, 2019).

High school experience signifies one's precollege preparedness or readiness for STEM study, including high school type (selective high school=1, other=0), track (science=1, huminites=0), *Gaokao* total score (standardized by province-year-track).[18] Selective high schools include national, provincial-level key high schools. Students at advantaged high schools are

[17] In the Hukou system, the citizen was classified as rural or urban based on the location of origin.
[18] Since the examination for each track is conducted separately by each provincial-level administrative division and is only comparable within this level, the *Gaokao* scores are standardized based on the score distribution of all students in a given province-year-track instead of the sampled students. The supplementary score data of all students taking the same track of exam in the same province and year is used to make the calculation. Therefore, the mean of the scores in the sample does not necessarily equal 0.

instructed by higher-quality teachers and surrounded by higher-achieving peers (Landaud et al., 2020). They may have sufficient information and appropriate guidance in their major choice. Students in different tracks are sorted into different majors, for example, most of the STEM majors are only restricted to students in the science track. Students' "actual control" over their performance, like their test scores, also supports or impedes their educational choices (Zhang, 2019).

Results

Descriptive Statistics

Table 2.2 presents the percentage of students by major categories using all sampled students or subsample of students in the science track in high school. Females are substantially underrepresented in STEM. The majority of students major in engineering, for example, 66.52% of male students in the science track are admitted to engineering majors. The share of female students in engineering is relatively small, while 24.47% of them major in economics or management. The share of students in each major category is largely determined by the setting of major quotas by universities.

Table 2.2 College Majors by Gender (Percentage of Students)

Major	All students		Science-track students	
	Female	Male	Female	Male
Economics	13.92	7.76	11.13	5.61
Law	7.16	3.48	2.84	1.26
Education	0.77	0.89	1.10	0.81
Literature	20.63	4.97	8.76	2.17
History	0.95	0.77	0.08	0.05
Science	5.77	11.20	9.47	13.18

Engineering	25.36	57.19	42.62	66.52
Agriculture	2.48	1.13	3.63	1.21
Medical	0.41	0.49	0.71	0.56
Management	16.08	8.53	16.34	6.77
Art	6.49	3.60	3.31	1.87
Total	100	100	100	100

Note. The table presents the actual college major by gender of all sampled students and science-track students. The numbers are the percentages of female or male students majoring in each field of study. The major categories are based on the college major list published by the Ministry of Education of China.

Table 2.3 summarizes the descriptions of the main variables based on the survey sample, separately for male and female students. The summary statistics show that 50.8% of the sampled students major in STEM, and the percentage is 68.4% and 31.1% for males and females, respectively. The difference in the share of students in STEM across gender is significant at a 1% level. The factor score of gender role beliefs is significantly lower for female students, indicating that they disagree more with the traditional and negative attitudes towards females. This is consistent with prior literature in that the traditional gender role beliefs are more endorsed by males (Brewster & Padavic, 2000). Next, female students in the survey sample come from statistically significantly more advantaged family backgrounds. In terms of high school experience, there are about three quarters of the students in the science track in high school, to be specific, 87.6% of male students choose the science track, while the percentage is much lower for female students (62.4%). More male students graduated from selective high schools and have higher standardized *Gaokao* scores.

Table 2.3 Sample Summary Statistics

	Total	Female	Male	Diff.
STEM major choice	0.508	0.311	0.684	-0.373***
	(0.500)	(0.463)	(0.465)	
Gender role beliefs	0.000	-0.250	0.225	-0.475***
	(0.823)	(0.797)	(0.780)	
Family SES	0.000	0.089	-0.079	0.167***
	(0.900)	(0.897)	(0.896)	
High school science track	0.757	0.624	0.876	-0.253***
	(0.429)	(0.485)	(0.329)	
Selective high school	0.597	0.571	0.621	-0.050***
	(0.491)	(0.495)	(0.485)	
Standardized *Gaokao* total score	-0.110	-0.156	-0.068	-0.088**
	(1.240)	(1.071)	(1.377)	
N	4,694	2,220	2,474	.

Note. The last column shows the results of t-tests comparing the means across the male and female groups. The coefficients are the mean or difference between the group. Std. Dev. in parentheses. ***, ** and * indicate statistical significance levels of 0.01, 0.05 and 0.10, respectively.

Main Results

Table 2.4 presents the results of the logistic regression models. Compared to male students, female students are 74.10% (1-exp(-1.351)) less likely to get admitted to a STEM major even though when they have similar family backgrounds and college preparedness in terms of high school type, track, and academic performance (see Column 3). Students from more advantaged family backgrounds with higher SES scores are less likely to major in STEM (see Column 2). In addition, high school experiences could explain a part of gender gaps in STEM major choices as the coefficient of females decreases when high school experiences are controlled (see Columns 2-3). To be more specific, students in the science track, graduated from selective high schools and with higher *Gaokao* scores are more likely to apply to and enroll in STEM majors. The key independent variable of interest, i.e., the index of gender role beliefs, is added to the model afterward, and the result shows that overall it is not associated with college major choice for all students (see Column 4). Finally, an interaction term between female and gender role beliefs is added to the model to see if the relationship between gender role beliefs and STEM major choice depends on one's gender. The result in Column (5) shows that the insignificant effect of gender role beliefs is masked by the significant heterogeneity in the roles of beliefs across gender. To be specific, female students with more traditional gender role beliefs are more likely to major in STEM.

Table 2.4 Gender Role Beliefs and STEM Major Choice

VARIABLES	(1) STEM	(2) STEM	(3) STEM	(4) STEM	(5) STEM
Female	-1.654***	-1.631***	-1.351***	-1.366***	-1.378***
	(0.075)	(0.075)	(0.091)	(0.095)	(0.096)
Family SES		-0.166***	-0.190***	-0.190***	-0.182***
		(0.042)	(0.053)	(0.053)	(0.053)
Gender role beliefs				-0.030	-0.166*
				(0.057)	(0.085)
Female # Gender role beliefs					0.251**
					(0.116)
Constant	0.961***	0.939***	-4.246***	-4.240***	-4.211***
	(0.053)	(0.053)	(0.417)	(0.417)	(0.418)
Observations	3,398	3,398	3,398	3,398	3,398
High school covariates	No	No	YES	YES	YES

Note. This table reports the result of logistic regression. Robust standard errors are in parentheses. ***, ** and * indicate statistical significance levels of 0.01, 0.05 and 0.10, respectively.

Moreover, I take a close look at the relationship between STEM major choice and each specific item for gender role beliefs. I replace the factor score of gender role beliefs with binary variables indicating traditional gender role beliefs related to the inherent ability, tradeoff between family and career, comparison between career and marriage, and the position in the labor market. The results are shown in Table 2.5. Consistently, females with more traditional gender beliefs, especially those who believe that males are inherently better than females, are more likely to enter STEM majors.

Table 2.5 Gender Role Beliefs and STEM Major Choice (Specific Items)

	(1)	(2)	(3)	(4)
	Dep var: STEM major			
VARIABLES	Perceived gender difference in ability	Career-family tradeoff	Career/marriage comparison	Position in the labor market
Female	-1.475***	-1.438***	-1.460***	-1.404***
	(0.106)	(0.116)	(0.110)	(0.095)
Family SES	-0.183***	-0.189***	-0.191***	-0.186***
	(0.053)	(0.053)	(0.053)	(0.053)
Gender role beliefs	-0.269*	-0.097	-0.156	-0.430**
	(0.140)	(0.131)	(0.138)	(0.204)
Female # Gender role beliefs	0.493**	0.242	0.342*	0.621*
	(0.213)	(0.190)	(0.194)	(0.376)
Constant	-4.183***	-4.205***	-4.189***	-4.201***
	(0.419)	(0.421)	(0.420)	(0.418)
Observations	3,398	3,398	3,398	3,398
High school covariates	YES	YES	YES	YES

Note. This table reports the result of logistic regression. The main independent variables are the specific items for gender role beliefs. Robust standard errors are in parentheses. ***, ** and * indicate statistical significance levels of 0.01, 0.05 and 0.10, respectively.

Robustness

A series of robustness checks are conducted to show the stability of the results to several alternative specifications (see Table 2.6). First, I conduct the same regression for the subsample of science-track students since most of the STEM majors only admit students in this specific high school track (see column 1). Second, I replace the key independent variable gender role beliefs with an alternative measurement, i.e., the standardized sum score of the items (see Column 2). Next, I examine whether the result is robust to using a linear probability model.

Finally, one concern for the measurement of gender roles is they were collected during students' college years and after choosing a major. The analysis is based on the assumption that these beliefs are ingrained and consistent during their 20s. Another study has shown that the students' non-cognitive dispositions are consistent over time (Hu & Wu, 2019). As a supplementary analysis to address this concern, I explore to what extent gender role beliefs are associated with choosing a STEM major in graduate programs. The information on the graduate major is collected after students report their gender-related beliefs.

Consistent with the prior finding, all the results show that the associations between gender role beliefs and STEM major choices for female and male students are significantly different, and traditional gender role beliefs predict STEM major choices for females.

Table 2.6 Gender Role Beliefs and STEM Major Choice (Alternative Sample, Measurement, and Model)

	(1)	(2)	(3)	(4)
	Dep var: STEM major			STEM graduate program
VARIABLES	A subsample of science-track student	An alternative measurement of gender role	Linear probability model	
Female	-1.378***	-1.378***	-0.228***	-1.039***
	(0.097)	(0.096)	(0.014)	(0.147)
Family SES	-0.186***	-0.183***	-0.023***	-0.017
	(0.054)	(0.053)	(0.008)	(0.075)
Gender role beliefs	-0.184**	-0.128*	-0.019	-0.145
	(0.086)	(0.070)	(0.012)	(0.106)
Female # Gender role beliefs	0.271**	0.184*	0.032*	0.324*
	(0.117)	(0.095)	(0.017)	(0.186)
Constant	1.397***	-4.212***	0.164***	-0.813***
	(0.091)	(0.418)	(0.019)	(0.083)
Observations	2,586	3,398	3,398	1,376
High school covariates	YES	YES	YES	YES

Note. Columns (1), (2), and (4) report the result of logistic regression. The dependent variable of the first three columns is whether a student is admitted to a STEM undergraduate major (STEM=1, other=0). The dependent variable of the last column is whether the student is admitted to a STEM graduate program (STEM=1, other=0). Robust standard errors are in parentheses. ***, ** and * indicate statistical significance levels of 0.01, 0.05 and 0.10, respectively.

Heterogeneity

I investigate how the relationships between gender role beliefs and major choices could be different across various major categories and institutional settings (see Table 2.7). First, considering that economics and management are also math-intensive majors, I extend the analysis by replacing the outcome variable STEM majors with math-intensive majors. The result in Column (1) indicates that the gender role beliefs also impact the students' choice of math-intensive majors differently for females and males.

Second, I explore whether the pattern appears in biology and biomedical majors, where women usually outnumber men. As shown in Column (2), the coefficient of females suggests that the gender gap in STEM does not exist in biology-related majors, which is consistent with findings from other contexts, such as the United States. Moreover, in contrast to the main result, the probability of majoring in biology is negatively related to traditional gender role beliefs. Women with more egalitarian views about gender roles are more likely to enter the biological field.

Next, I categorize the STEM majors into three groups based on their popularity. In the recent internet era, STEM majors, especially majors such as computer science and artificial intelligence become popular majors to pursue among high school graduates. "Hot" or advantaged STEM majors are fields of study attached with high wage premiums in the Chinese context, such as information technology and computer science. In contrast, biology, chemistry, environment, and materials are four widely acknowledged "cold" or disadvantaged majors in China. Other STEM majors without generally accepted standards of "hot" or "cold" are categorized into other majors. Student major selection behavior could be very different across different specific majors in the STEM field. A multinomial logistic regression is used to estimate the probabilities of entering each of these three STEM major categories compared to non-STEM majors. The gender gap in advantaged STEM majors is the largest, while the gap is the smallest in disadvantaged STEM majors after ruling out the impacts of students' family background, high school experiences and beliefs. The underrepresentation of women becomes larger with the increase of the "value" of STEM majors. Another noteworthy finding is that the gender differences in the role of gender role belief only exist in disadvantaged or other STEM majors. There is no statistically significant association between gender role beliefs and advantaged STEM major choices nor gender differences in this association.

Finally, I also investigate how the results will be different when the selectivity of universities is taken into account. There is a clear institutional stratification in the Chinese higher education system. Project 985 includes 39 most prestigious universities designated as world-class in China. I rerun the baseline model separately for the subsamples of elite universities and other universities. The results in Columns (7) and (8) show that the index of gender role beliefs is only significant for predicting the enrollment of STEM majors at non-selective universities.

Table 2.7 Heterogeneity by Major Categories and Institution Type

VARIABLES	(1) Math-intensive majors	(2) Biology	(4) Advantaged STEM	(5) Disadvantaged STEM	(6) Other STEM	(7) Dep var: STEM major Selective universities	(8) Non-selective universities
Female	-0.780***	0.214	-1.186***	-0.924***	-1.632***	-1.570***	-1.677***
	(0.107)	(0.234)	(0.129)	(0.143)	(0.110)	(0.116)	(0.105)
Family SES	-0.139**	-0.237*	-0.084	-0.285***	-0.205***	-0.140**	-0.248***
	(0.056)	(0.126)	(0.070)	(0.080)	(0.060)	(0.062)	(0.060)
Gender role beliefs	-0.046	0.122	-0.133	-0.301**	-0.143	0.106	-0.190**
	(0.102)	(0.202)	(0.107)	(0.123)	(0.090)	(0.095)	(0.095)
Female # Gender role beliefs	0.293**	-0.568**	0.236	0.288*	0.266**	-0.167	0.359***
	(0.127)	(0.272)	(0.156)	(0.174)	(0.133)	(0.141)	(0.126)
Constant	0.352***	-3.560***	-18.276	-5.663***	-4.484***	0.807***	0.810***
	(0.125)	(0.204)	(450.329)	(0.720)	(0.509)	(0.115)	(0.100)
Observations	3,398	3,591	3,398	3,398	3,398	1,620	1,971
High school covariates	YES	YES	YES	YES	YES	YES	YES

Note. Columns (1) and (2) report the result of logistic regression using whether a student is admitted to a math-intensive major or biology major as the dependent variables. Columns (4)-(6) report the results of a multinomial logistic regression, which estimates the probabilities of entering advantaged STEM, disadvantaged STEM and other STEM majors versus the reference group, i.e., non-STEM majors. Columns (7)-(8) are the results of logistic regression using the subsamples of selective and non-selective universities. Robust standard errors are in parentheses. ***, ** and * indicate statistical significance levels of 0.01, 0.05 and 0.10, respectively.

Another important dimension of the heterogeneity in the role of gender role beliefs is different student characteristics (see Table 2.8). The gender role belief is strongly related to STEM majors for females with urban hukou and from southern regions. Additionally, the association of gender role beliefs with STEM major choice is substantial for females who graduated from non-selective high schools and with a relatively lower academic ability. Overall, the effects of gender role beliefs are pronounced for students from relatively advantaged places of origin but with relatively poorer college preparedness.

Table 2.8 Heterogeneity by Student Characteristics

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dep var: STEM major							
	Hukou		Region		High school type		*Gaokao* score	
VARIABLES	Urban	Rural	South region	Others	Selective	Non-selective	High-achieving	Other
Female	-1.367***	-1.400***	-1.403***	-1.263***	-1.427***	-1.324***	-1.213***	-1.423***
	(0.114)	(0.182)	(0.123)	(0.161)	(0.130)	(0.144)	(0.216)	(0.108)
Family SES	-0.118	-0.007	-0.125*	-0.267***	-0.266***	-0.072	-0.049	-0.234***
	(0.072)	(0.213)	(0.068)	(0.090)	(0.071)	(0.082)	(0.120)	(0.060)
Gender role beliefs	-0.247**	0.052	-0.222**	-0.055	-0.065	-0.288**	-0.157	-0.163*
	(0.100)	(0.166)	(0.111)	(0.139)	(0.115)	(0.128)	(0.186)	(0.096)
Female # Gender role beliefs	0.232*	0.293	0.274*	0.155	0.106	0.420**	-0.052	0.321**
	(0.136)	(0.226)	(0.150)	(0.191)	(0.158)	(0.172)	(0.264)	(0.130)
Constant	-3.759***	1.534***	-3.942***	-4.467***	-4.201***	-3.872***	0.643	-4.019***
	(0.422)	(0.269)	(0.512)	(0.724)	(0.583)	(0.586)	(0.449)	(0.420)
Observations	2,370	829	1,991	1,407	1,948	1,450	536	2,737
High school covariates	YES	YES	YES	YES	YES	YES	YES	YES

Note. This table reports the result of subsample regressions. Robust standard errors are in parentheses. ***, ** and * indicate statistical significance levels of 0.01, 0.05 and 0.10, respectively.

Discussion and Conclusion

The analyses reported here reflect that female students are substantially underrepresented in most STEM majors, and that they are about 70 percentage points less likely to get admitted to a STEM major even when they have a similar level of college preparedness as males. The STEM major choice patterns appear to differ for men and women. Importantly, the gender role belief can be one potential underlying psychological factor that explains the gender disparity in STEM major choices. Female students have relatively more positive gender role attitudes towards themselves. However, females with more traditional gender-role beliefs are more likely to major in STEM. This result is robust when analyzing the subsample of science-track students, using alternative measurements of gender role beliefs, applying a linear regression model, and examining the major choices at the graduate level. The math-intensive nature and differentiation within STEM majors are also considered in the analyses. The role of traditional gender role beliefs for females still exists in the broad math-intensive majors, the non-advantaged subset of STEM majors, and STEM majors at non-selective universities. Additionally, the pattern exists for students who originate from more advanced household statuses and regions, but not for high-achieving students.

In the STEM field, masculinity continues to occupy a privileged position and the male privilege is endorsed by females entering this field. To choose hard-core STEM, women must feel similar to those occupy in the field, and in this case, similarity in gender role norms and beliefs (Gabay-Egozi et al., 2015). Gender assimilation is happening in the STEM field, that the minority group (females) comes to resemble the majority group (males) in values and beliefs. Females attempt to integrate themselves into the dominant culture in STEM with the sacrifice of self-identity or femininity. Internalized sexism or misogyny means that women may minimize the value of women while believing gender bias in favor of men (Szymanski et al., 2009). Under the oppression of the powerful and dominant group, women even are drawn into the in-group discrimination and internalize the oppression. One possible reason is that they are afraid of losing the social rewards of adopting the dominant values (Szymanski et al., 2009). And this kind of self-stereotyping may also increase self-esteem by internalizing the gender norms assumed by the dominant into their own gender identity (Glick & Fiske, 1999).

However, this kind of assimilation only works for relatively inferior STEM fields in terms of the value of majors and the level of institutions. Moreover, it may exert negative impacts on students' attitudes and performance in the domain. I further investigate whether females will be interested in their college majors once they enter STEM with a traditional gender role. I find that although females with more traditional gender roles are more likely to choose a STEM major, they appear to be less interested in their fields of study. Finally, it is important to acknowledge that this mechanism works in the opposite direction in majors that are more inclusive or friendly to females, like biology.

In addition, the results could also be interpreted from the perspective of the flexibility or the degree of freedom of students' choices. Students with traditional gender roles are more likely to stick with their high school track and choose familiar majors, while students with more egalitarian gender role beliefs are more likely to enter majors that are not directly related to their high school subjects and divert from the STEM fields.

It should be acknowledged that the findings should be interpreted within the context of the following limitations. First, the study only uses endogenous variables to explain the correlations between gender role beliefs and college major choice without implying a causal relationship. Second, the self-reported measurements of non-cognition dispositions may be biased, and the magnitude of bias may be related to gender. The subjects may forget or misremember details, may be influenced by the context and time when filling out the questionnaire, may exaggerate or understate the fact deliberately, or refuse to answer specific questions. These various measurement errors may bias the results. Third, although the survey contains a rich set of variables that can be used in the study, it is not designed for this specific study and the analysis is restricted by the available variables. For example, the survey only provides information on parental occupation about specialty or the level of responsibility instead of the occupational field, like the sector or industry, which has been found as an important family factor affecting both individual gender roles and major choice (e.g., Aydede, 2020).

Future studies could continue the discussions about the relationships between gender role beliefs and students' long-term performance, such as the trajectory of education (e.g.,. persistence in STEM fields) and career (e.g., STEM occupational attainment) over time. Moreover, a more in-depth investigation into the underlying mechanisms of gender roles will be valuable, such as the role of family in constructing such benefits, and its interaction with other important psychological factors, e.g., self-efficacy and self-esteem.

Appendix A. Identity / Positionality

As a female student from China, I have been engaged in the Chinese centralized education system for nearly twenty years and received seven years of higher education at elite institutions in China. I have direct experiences with the selection system and education pipeline, and a broad understanding of the challenges and barriers that students face in the world's largest education system, especially for students from disadvantaged backgrounds. Their family, social, or economic circumstances hinder their ability to maximize their educational potential and optimize their education choice. I want to investigate their conditions closely and critically and utilize information nudges to improve their education decisions.

Before my college application, I had a great interest in engineering and intended to follow in my parents' footsteps in the engineering profession. At an early age, I immensely enjoyed visiting the industrial plants, playing with simple machines and instruments, and investigating how they work. During my high school years, I maintained high grades in high school science subjects, ranked at the top in a science-track class, and won prizes in national mathematics and science contests. The results from a career test also indicated that engineering is the profession that best suits my interests, skills, and personality. I was determined to choose a STEM major, but my parents and high school teachers completely changed my final choice. Although my parents are working in the STEM field, they perceived the field as relatively masculine, extremely difficult with a high workload, not appropriate for women to work in, and challenging for women to succeed. Instead, they expected me to pursue some "lighter" fields of study, like economics and management, which are both lucrative and friendly to women. At that point, I lacked sufficient information and knowledge about majors and occupations to persuade them to let me stick on my original aspiration. Finally, I compromised and obeyed their choice.

Upon entering university, I struggled for a long time with whether to transfer major or retake the college entrance examination and reapply for a STEM major instead. There was a good opportunity for me to change my major in my freshman year. My university established a new science experiential class at that year. It is quite similar to the meta-major I am studying in this dissertation. The class also includes many related fundamental science majors, but the difference is that it recruits students who have already been admitted to this institution. It was a very good opportunity to transfer to another major. However, I was scared off by the uncertainties. It was a brand new experimental class; it was the first year of its implementation, nobody had experience with how it works and whether it would be beneficial for students like me, and I had to choose a major again after one year. It could be really risky for me. So, I missed the chance to enter STEM again. Although I finally finished my coursework in economics successfully, I still occasionally think about what it would be if I insisted on my interest at that time.

After many years, when I was engaged in a consulting project that helped high school students to complete their college applications, I observed that most of the high school graduate students were in a similar condition as me in the past. They and their families lack sufficient information and appropriate guidance in college major choices, especially for students from disadvantaged families or poor regions of China. I want to investigate these problems closely and do something to maximize their educational potential and help them to make better choices.

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Chapter 3 The Impacts of College Major Reforms on Student Composition in China

Abstract

In the context of the Chinese meta-major reform, this paper provides one of the first empirical evidence on the consequences of a transition from college-major to college-then-major choice mechanism. Using administrative data on college admissions over 18 years, I study the impacts of the staggered adoption of the reform across institutions on student composition. I do not find aggregately statistically significant effects of the meta-major reform on the distribution of ability and demographic characteristics of students by college-majors. The result is robust to using alternative measurements, samples, models, and estimators. However, the aggregate null effects are masked by the heterogeneity across institutions and majors. The impact of increasing admission scores is predominantly concentrated in non-elite institutions and non-advantaged STEM majors. The reform also alters the student profile in terms of ethnicity and place of origin at the most prestigious institutions.

Keywords: College major choice, Meta-major reform, Student composition

Introduction

Various supply-side policies in higher education, such as tuition, admissions criteria, and targeted financial aid, have been used to alter the composition of college majors (Patnaik et al., 2020). In China, a substantial college admissions reform allowing a subset of universities to switch from the jointly college-major admissions to sequentially college-then-major admissions was recently started and potentially changing the composition of students across higher education institutions. Colleges undertaking the reform cluster relevant majors to form a larger meta-major, for example, an engineering meta-major includes all engineering-related majors. Students could be admitted to a meta-major first at the entrance of college, and then decide their final major within the scope of the meta-major after one or two years of education under the general field of study. Therefore, the meta major can be interpreted as an intermediate form between college-major admissions and college-then-major admissions. For institutions, meta-major is an important practice of multidisciplinary education and cultivating interdisciplinary talents, which are essential for scientific and technological development and innovation. It also alleviates the polarization between popular and unpopular majors in student quality. For students, meta-major reduces the initial number of major options available for entering students and also postpones the timing of the ultimate major choice. However, students face great uncertainties in the final major declaration and the risk of being assigned to a less preferred major.

The meta-major reform is one of the most important university-level reforms in shifting from college-major choice to college-then major choice mechanism in China, potentially affecting students' educational and career choices. However, we know little about how students' college choices and admissions results would be affected by this transition between different major choice mechanisms. This paper provides one of the first quasi-experimental evidence on the consequences of the college-major to college-then-major reform on student composition. This study is guided by the following research question:

1. How would the student composition within college-major change after the meta-major reform?

I use the administrative data over 18 years on the universe of students' college-major admissions outcomes in a provincial-level complete college admission market, which provides information on students' demographic characteristics, college preparedness, and college-major admission results. I investigate how the transition from college-major to college-then-major choice, i.e., the meta-major reform in the Chinese context, affects student composition within college-major. I find that aggregately, there are no statistically significant changes in student composition in college-majors after the implementation of the meta-major reform. The result is robust to using alternative measurements, samples, models, and estimators. The heterogeneous impacts across different institutional types and major categories supplement the main results. Meta-major reform disproportionately increases the student quality at non-elite universities and non-advantaged STEM majors. The reform also alters the student profile in terms of ethnicity and place of origin at the most prestigious institutions.

The results contribute to three strands of literature. First, a large body of previous literature has documented the supply-side factors of college major choices (Patnaik et al., 2020). This paper extends the discussion on how the major policies at the university-level would affect students' choice behaviors. Second, the results speak to recent studies on mechanism designs of college major choice. The paper contributes new empirical evidence on the ongoing reforms of college major policies, i.e., the transitions between college-major and college-then-major choices (Bordon & Fu, 2015). Third, the paper also contributes to the debate over the access equity of higher education by investigating how the meta-major reform may disproportionately impact students from different backgrounds (Kanny et al., 2014). Moreover, the investigation of how the meta-major affects students' application behaviors also has important implications for promoting better admission practices and policies of universities worldwide that are alternating between college-major and college-then-major choices.

Background

Like many other countries, such as Chile, Japan, and Spain, students in China usually choose college and majors jointly in the centralized college admissions system. In the shift from college-major choice to college-then major choice in China, one of the most important university-level reforms is the implementation of the meta majors, which clusters relevant academic majors into a larger cohesive bucket (e.g., in clusters of science, engineering, medical, business, liberal arts, social science). The reform aims to consolidate the foundation of both general and major-specific knowledge, as well as provide a wide range of major and career opportunities under the general field of study. From the perspective of higher education institutions, the meta-major is a potential approach to attract talented students by providing multidisciplinary education and broader career prospects. In 2011, almost all the most selective universities under the Project-985 program and more than 50% of Project-211 universities had implemented the reform of meta major (Li & Luo, 2012).[19]

The reform in college majors simplifies student major choice by reducing the initial number of major options available for entering students and postponing the timing of the

[19] Project-985 includes 39 universities designated as world-class in May 1998, and Project-211 is a broader group of key universities in the 21st Century including 112 universities.

ultimate major choice. Similar to the conventional college-then-major choice (e.g., in the United States), students have to declare a major in a specific discipline after enrolling in general courses related to the areas of study under the meta major, and the final major choice is based on individual preference and academic performance. The assignment mechanisms of meta majors are different across universities, students' final major choice in these programs may be determined by their *Gaokao* scores, academic performance in the first or two years after enrollment, the scores of tests specifically designed for assignment, etc. The specific major assignment mechanisms could be complicated and vary across colleges, and students are faced with great uncertainty in their final major choices. One potential risk of meta majors is that students may be under greater academic pressure in the first few years of college and end up being assigned to a less preferred major.

Using a hypothetical student to illustrate the reform: a high school graduate student is interested in mechanical engineering and makes her college application based on her major interest. Before the reform, she could apply directly to a mechanical engineering major in a couple of universities and will be admitted to a college-major option when she passes its admission threshold. After the reform, if an institution that she would like to choose has already conducted the meta major reform, she must choose the engineering meta major instead, which contains a lot of majors related to engineering, such as mechanical engineering, aeronautical engineering, energy and power engineering, and vehicle engineering. It is uncertain whether she would enter the mechanical engineering major after one or two years of study. For example, if the final major choice is determined by student GPA, she will miss her favorite major once the number of students with higher GPAs listing mechanical engineering as their first choice exceeds the quota for the major. And she will be admitted to her second or subsequent less preferred majors.

Related Literature

Various supply-side factors affect students' college major choices and could be used to alter the student composition across different majors, e.g., tuition and financial aid, admissions criteria, etc. (Patnaik et al., 2020). Students' demands for majors are related to the major-specific costs, the probability of obtaining financial aid, and the workload and grading standards (Stange, 2015; Evans, 2017; Ahn et al., 2019). Universities could change the majors they offer and the way they allocate students to different majors. The college major settings are different across institutions based on their capacity constraint, such as faculty, and facilities (Patnaik et al., 2020). In China, colleges of different types, like comprehensive, polytechnic, and medical universities, provide different sets of majors based on their specializations. The majors provided also depend on the selectivity of institutions. The major categories at key universities, regular provincial and local four-year colleges are different from those provided at tertiary vocational colleges in China, which usually offer more practical knowledge and training. In terms of admission, universities establish their admission criteria, usually solely based on *Gaokao* scores, to admit and allocate students to different majors following students' list of preferences.

Most relevant to this paper, the timing of specialization across different admission systems is also an important determinant of students' college major choices and their subsequent careers and welfare. Malamud (2010, 2011) studies the labor market outcomes across various admission systems, i.e., joint or sequential college and major choice mechanisms. He found that although there is no significant difference in earnings, individuals are less likely to switch to an unrelated occupation under the sequential choice system (Malamud, 2010, 2011). The results imply that the benefit of the student-major match outweighs the loss of early specialized education (Malamud, 2011). More recently, Bordon & Fu (2015) study the impacts of postponing the timing of college major choice by developing a sorting equilibrium model under the college-major-specific choice regime. The model allows for uncertainties over student-major fits and endogenous peer quality that affects individual outcomes. They found that switching from the joint choice to the counterfactual regime (sequential choice) leads to a 1 % increase in average student welfare, with larger impacts on female, low-income, and/or low-ability students (Bordon & Fu, 2015). These studies contribute important evidence for us to understand those different admission mechanisms, but we know little about how students would behaviorally respond to these two systems in their college application and major choices. The paper aims to extend the discussion by exploring how the student composition will change because of the transition of college major choice mechanisms.

Data and Method

This paper sues the administrative data on college admission in the province of Ningxia (2001-2018) provided by the Ningxia Department of Education. The administrative data includes information on the demographic characteristics, high school experience, college application and admission results for all high school graduates in Ningxia province from 2001 to 2018.

Figure 3.1 shows the trend in the total number of high school graduates and the number of graduates in each track at high school (science or humanities). The student body increased over time with a rapid rise before 2009 and fluctuated upward after 2009. The trend is similar for students in different tracks, and science-track students are about twice as many as humanities-track students.

Figure 3.1 Number of High School Graduates (2001-2018)

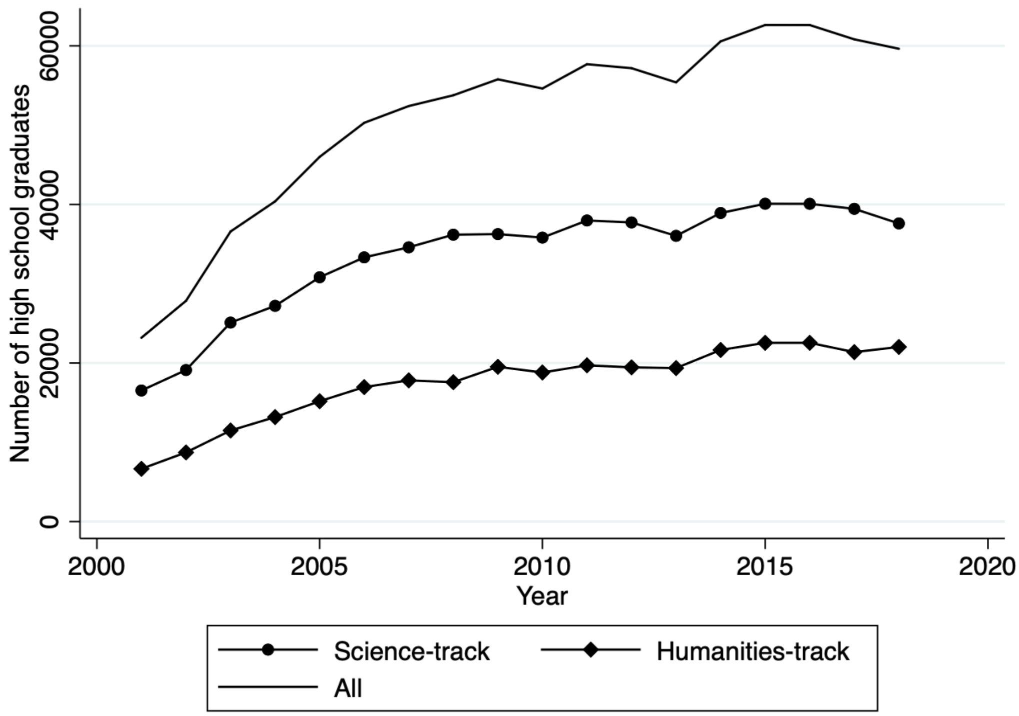
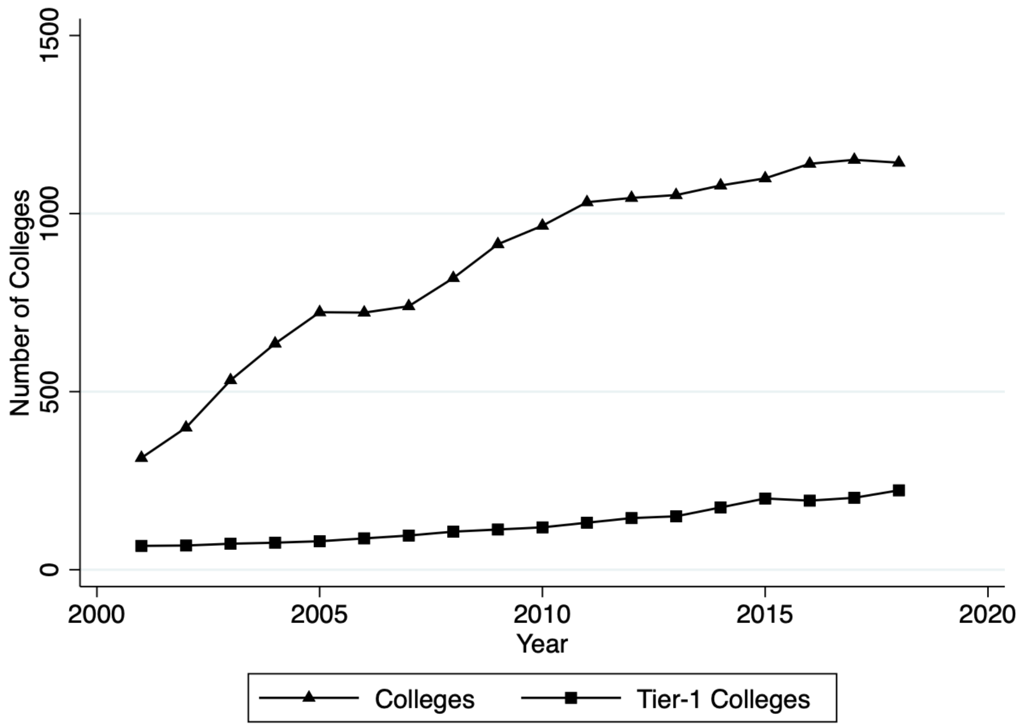


Figure 3.2 illustrates the number of colleges recruiting students in Ningxia from 2001 to 2018. The total number of colleges increased 264% from 314 to above 1000 during these 18 years, and the number of tier-1 colleges also rose steadily since 2001 with more than 200 of them in 2018.[20]

[20] The tier-1 colleges here refer to colleges with admission scores above the first-tier cutoff, which is a larger subset of universities than what we usually define as "yiben," i.e., the first batch of universities with the highest admission scores.

Figure 3.2 Number of Colleges (2001-2018)



The final sample consists of 120,576 students whose *Gaokao* score is above the first-tier cutoff score of their given track. It is worth mentioning that the data of the Ningxia is representative of the national population because the admissions mechanisms and the student application behavior in this province are highly similar to other areas in China (Chen et al., 2018).

Table 3.1 presents the descriptive statistics of the main variables, aggregately and separately by five selected years. A noteworthy trend is that the share of female and ethnic minority students increased over time. The fraction of students with rural hukou or from poor counties increased during the early years but decreased slightly recently. The share of *Gaokao* repeaters in recent years is about 18%.[21] Around 80% of students with *Gaokao* scores higher than the first-tier cutoff are in the science track.

Table 3.1 Descriptive Statistics

Variable	Total	2002	2006	2010	2014	2018
Female	0.488	0.396	0.435	0.496	0.501	0.529
	(0.500)	(0.489)	(0.496)	(0.500)	(0.500)	(0.500)
Han ethnic group	0.729	0.837	0.752	0.736	0.724	0.688
	(0.444)	(0.370)	(0.432)	(0.441)	(0.447)	(0.447)
Rural hukou	0.433	0.356	0.389	0.452	0.454	0.434
	(0.495)	(0.479)	(0.488)	(0.498)	(0.498)	(0.498)
Poor county	0.228	0.253	0.265	0.269	0.205	0.177
	(0.420)	(0.435)	(0.441)	(0.444)	(0.404)	(0.404)
Gaokao repeater	0.231	0.282	0.248	0.309	0.181	0.178
	(0.421)	(0.450)	(0.432)	(0.462)	(0.385)	(0.385)
Science-track	0.805	0.826	0.829	0.783	0.800	0.802
	(0.396)	(0.379)	(0.377)	(0.412)	(0.400)	(0.400)
Standardized *Gaokao* scores	1.477	1.677	1.697	1.554	1.381	1.261
	(0.478)	(0.491)	(0.395)	(0.433)	(0.433)	(0.433)
N	120,576	2,771	3,978	6,012	10,748	12,940

Note. The table reports the descriptive statistics of student characteristics. The coefficients are means and standard deviations are in parentheses.

To investigate how adopting a meta-major reform impacts the composition of students enrolled in college majors, the following two-way fixed effects model will be estimated:

$$Y_{ijt} = \beta_0 + \beta_1 \cdot Meta_{ijt} + \lambda_i + \mu_t + \varepsilon_{ijt} \quad (3\text{-}1)$$

[21] Gaokao repeaters are those who retake the college entrance examination because they fail or underperform in their first attempt, do not get admitted or are not satisfied with their admission results, and want to get higher scores and enter better colleges in the repeated year.

The outcome of interest (Y_{ijt}) is the average characteristics of students getting admitted to college-major i at college j in year t. All the outcome variables are aggregated at the college-major level. I am mainly interested in the following important characteristics of students, including the distribution of students' ability (described using the mean, median, minimum, maximum values, and range of the *Gaokao* scores),[22] the proportion of female students, students with rural residence (hukou),[23] students from nationally designated poor counties, and students who re-took the college entrance exam. $Meta_{ijt}$ refers to whether major i in college j adopted the meta-major reform in year t. β_1 is the effect of conducting the meta-major reform. The college-major fixed effects (λ_i) are added to control for time-invariant characteristics of college-majors that might be correlated with student composition and the decision to adopt the meta-major reform. The year fixed effects (μ_t) is used to control for common shocks that affect all students each year. All standard errors are clustered at the college level. The model performs a within-major analysis by comparing each college-major to itself before and after the reform. All regressions are weighted using the quota of each college-major, i.e., the number of admitted students.

Moreover, to capture the dynamic effects of the meta-major reform, the following event study design will be conducted:

$$Y_{ijt} = \beta_0 + \sum_{m=-12}^{12} \beta_m \cdot M_{ijt}^{m} + \lambda_i + \mu_t + \varepsilon_{ijt} \qquad (3\text{-}2)$$

[22] These values measure different aspects of the ability of the admitted students. Both the mean and medium values measure the central tendency of the admission scores, which is the average level of ability of admitted students. The mean value is sensitive to outliers, while the median value is more robust against outliners. The minimum value is the lowest qualifying score. Only students with scores above this cutoff score have the chance to enter the program. The maximum score describes the highest ability level of the students the program could attract. The score range is the difference between the maximum and minimum scores, which measures the variability of admitted students' test scores.

[23] In the Hukou system, each citizen was classified as being rural or urban based on the demographic variable, the "location of origin".

The effect of meta major reform is mapped to a set of dummy variables (M_{ijt}^{m}) indicating the number of years since the reform. The year before adopting the reform as m=-1, the year adopting the reform as m=0, and all remaining years are indexed relatively. β_m are the dynamic effects of the meta-major reform relative to one year before the event (the reference year). The other variables were defined as described previously.

The identification of the above equations relies on the parallel trend assumption that college-majors adopting the meta-major reform would have similar trends to other majors that did not adopt the reform if the reform had not occurred. The assumption could be tested using the falsification test by assessing whether the coefficients before the reform are statistically indistinguishable from zero. Although universities have the autonomy to decide whether to adopt the meta-major and what majors to be transformed, the adoption and the timing of the meta-major reform are exogenous conditional on the college-major and year fixed effects.

Results

Main Results

Table 3.2 shows the results of Equation (3-1), which estimates the impacts of meta-major reforms on admitted students' ability distribution and demographic characteristics over 12 years before or after the reform. Overall, the absolute scores increase with the range narrowing, but the distribution does not change significantly after the implementation of meta-majors (see Column 1-5). An exception is the increase in the minimum value of the admission score (2 points in the absolute *Gaokao* score), which is marginally significant (p-value = 0.094). There are also no substantial changes in students' gender, ethnicity, hukou status, and type of county. Based on the baseline model, the only significant change comes from the share of repeaters, which increases by 6.4 percentage points from the baseline mean of 23.7%. More discussions about this result will be provided in the following sections.

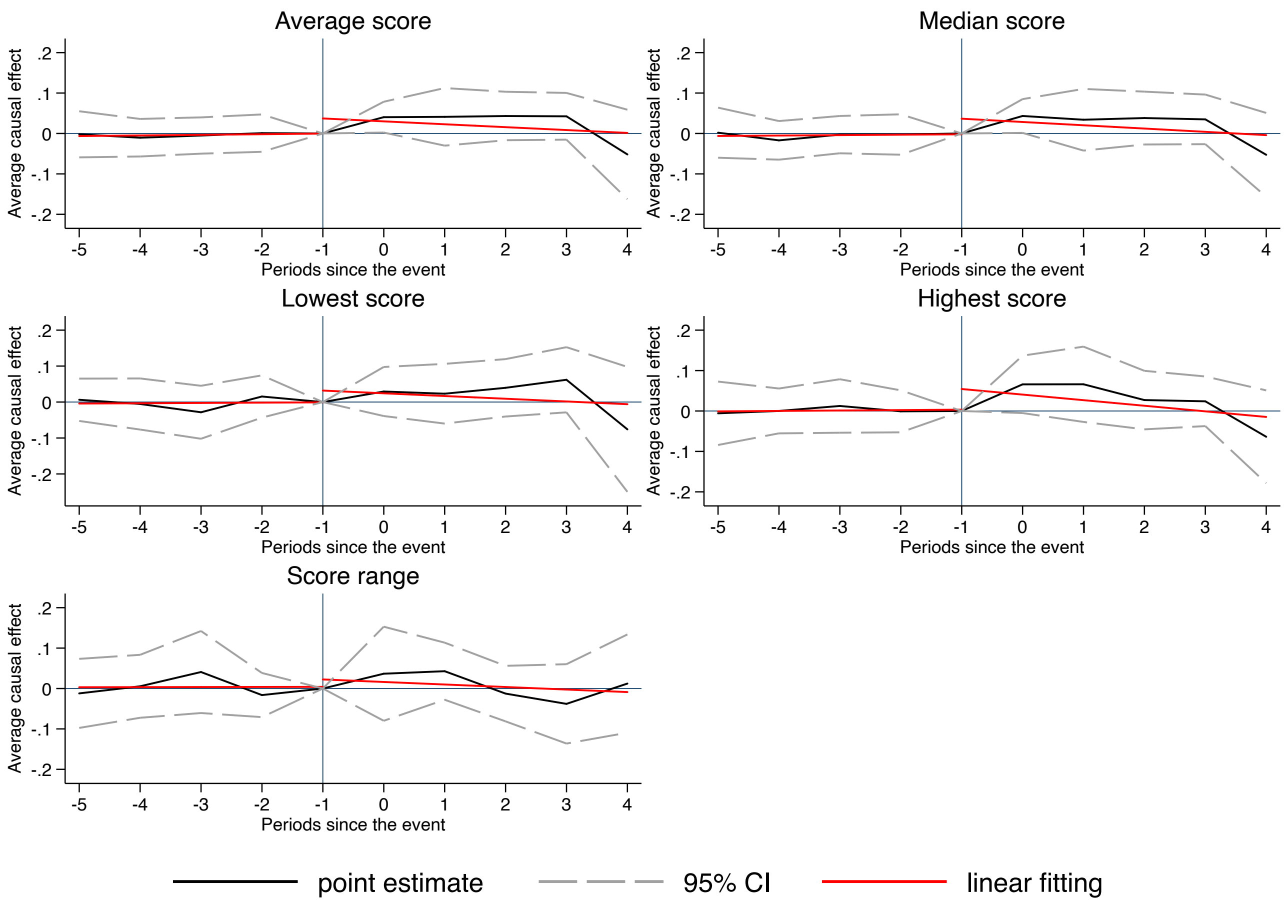
Table 3.2 Effects of Meta-Major Reform on Student Composition

VARIABLES	(1) Mean score	(2) Median score	(3) Minimum score	(4) Maximum score	(5) Score range	(6) Female	(7) Han ethnic group	(8) Rural hukou	(9) Poor county	(10) *Gaokao* repeater
Meta-major	0.034	0.030	0.047+	0.038	-0.009	0.004	0.007	-0.032	0.018	0.064**
	(0.022)	(0.022)	(0.028)	(0.029)	(0.027)	(0.016)	(0.022)	(0.022)	(0.022)	(0.019)
Constant	1.450***	1.455***	1.227***	1.678***	0.451***	0.486***	0.733***	0.435***	0.234***	0.237***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	35,487	35,487	35,487	35,487	35,487	35,487	35,487	35,487	35,487	35,487
College-major FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Notes. All regressions control for college-major and year fixed effects. Standard errors in parentheses are clustered at university level. ***, **, *, and + indicate statistical significance levels of 0.001, 0.01, 0.05 and 0.10, respectively.

Figure 3.3 presents the event study estimates from Equation (3-2). The *Gaokao* score distribution did not change substantially after the implementation of meta-majors. The pre-trends of the average, median, lowest, highest scores, and the score range are flatter after controlling for a set of fixed effects including the college-major and year fixed effects. The scores increase in the first year of the implementation, but then remain stable or drop and do not change substantially in the long term. Overall, no significant differences before and after the reform are observed. Appendix Table A. 3.1 reports the corresponding coefficient estimates in Columns (1) - (5).

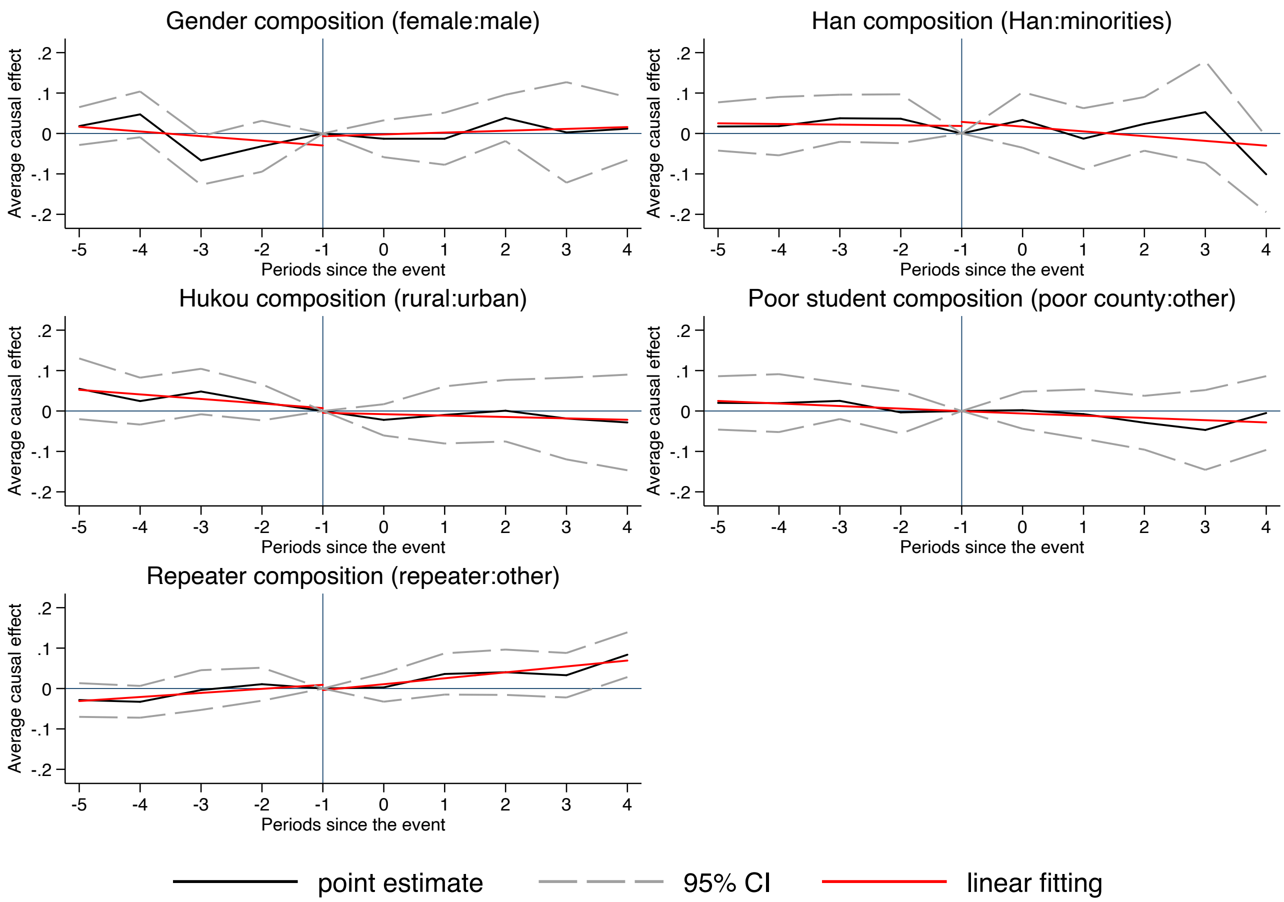
Figure 3.3 Event Study Results: Student Ability



Notes. The figure shows the event study estimates of the impact of meta major reform on admission scores distribution. The scores remain almost flat during the years before the reform and fluctuate after the reform, but no significant effect was found. The coefficient and standard error estimates are shown in Appendix Table A. 3.1.

Additionally, the student composition in terms of demographic characteristics also did not change substantially after the implementation of the meta-major. The proportion of female students, ethnic minority students, and students from poor counties stayed relatively similar after the reform, with a slight decrease in students from disadvantaged backgrounds (see Figure 3.4). The number of repeaters increased steadily, which indicates that there is a linear time trend in the share of repeaters. There is also a slightly decreasing time trend in the share of rural students. I will address this concern in the next section. Appendix Table A. 3.1 reports the corresponding coefficient estimates based on the event study in Columns (6)–(10).

Figure 3.4 Event Study Results: Student Characteristics



Notes. The figure shows the event study estimates of the impact of meta major reform on student composition. The coefficient and standard error estimates are shown in Appendix Table A. 3.1.

Robustness

A series of robustness checks are conducted. First, the meta-major adoption status or the year since adoption are used as the main independent variables in the prior analysis, I further allow for different treatment intensity by replacing them with the "size" of meta-majors, i.e., the number of specific majors included in the package of the meta-major. The more majors included in one meta-major, the more options for students to choose from in their final major decision, and the higher intensity of the implementation. For example, a science meta-major at one university is a large package of many STEM-related majors, including mechanical engineering, energy and power engineering, nuclear science and nuclear engineering, electronic information and electrical engineering, marine science and marine engineering, materials science and engineering, biomedical engineering and chemical engineering; while a computer science meta-major only combines highly relevant majors including computer science and technology and software engineering. The effect of the meta-major reform may depend on how broad the meta-majors are constructed.

Second, I restrict the sample to the years no earlier than 2009. Ningxia adopted the parallel admission mechanism reform in 2009, [24] which allows students to choose parallel colleges within the choice bands. Although the choices of majors within each college still follow a Boston mechanism,[25] the major choices of students could be altered as their selection sets of

[24] The Chinese parallel admission mechanism is similar to the Deferred Acceptance (DA) mechanism, in which students can choose parallel schools within the choice bands and will be accepted to their most preferred school for which they qualify (Machado & Szerman, 2021).

[25] Under the Boston mechanism (BM) or Immediate Acceptance (IA) mechanism, students submit an ordered list of schools/majors. The mechanism attempts to assign as many students to their first choice as possible, and only after all such assignments have been completed will it consider assigning students to their second choices, etc. (Abdulkadiroglu et al., 2006).

colleges are changed because of the college admissions mechanism transition. The main difference between these two admissions mechanisms is that the parallel admission mechanism allows students to reveal their true preferences and retain both risky and safe options in their application (Chen & Kesten, 2017). I investigate whether the effects of meta-major would change after the conduction of a parallel mechanism.

Third, I estimate the effects of the meta-major reform on student composition only for science-track students. As shown in the data description, most students are in the science track at high school (about 80%). And most of the meta-majors are placed in the STEM-related fields of study at colleges, which mainly admit science-track students.

Fourth, I restrict the sample to 5 years prior to and post the conduction of the meta-major reform to see whether the effects over a short period would be consistent with the main result.

Fifth, I measure whether an institution moving to meta-majors draws different types of students to the whole institution by replacing the outcome variables with the student composition at the institutional level. The meta-major reform may affect the sorting across majors (meta-major or traditionally specific major) within the institution and bring different effects for other specific majors and the cluster of all majors or the whole institution.

Sixth, I add the college linear time trends ($\nu_j \cdot t$) to Equation (4-1) to control for unobserved college characteristics that evolve over time. In the baseline model, I only control for the time-invariant college-major characteristics and the overall time trend. Adding the college linear time trends could further control for the potential different trends in student composition across colleges over time.

Table 3.3 indicates that first, the results remain almost the same when allowing for different treatment intensity and restricting the sample to recent years and science-track (see

Panels A-C). The only difference is that the effect of meta-major in decreasing the share of students with rural hukou becomes marginally significant when using the subsamples of students. Second, when the period for analysis is shortened, the effects on the mean and median scores are significant (Panel D). The result is consistent with the prior event study result that there is a significant increase in the early year of the reform. Next, Panel E shows that the meta-major reform may affect other unreformed majors and the whole institution to a greater extent as the effects for maximum score, score range, the share of students from Han ethnic group, rural hukou, and poor county become larger and more significant (marginally). Lastly, the results after adding college linear time trends exhibit some different results. The effects on admission scores are marginal significant in terms of mean and median scores. The previously significant effect on the share of repeaters disappears after ruling out the linear time trend, while the positive effects on the share of females and the negative effect on students from poor counties become marginally significant. Appendix Figure B. 3.1 presents the event study estimates after adding the college-specific linear time trend. We can see the previously visible time trends in students' hukou and repeat status become much flatter. However, a linear trend in the share of students from poor counties appears. This means that there are different trends in the share of poor students across treated and nontreated institutions over time, the fraction of poor students getting admitted to meta-major is increasing by year at the institutional level.

Table 3.3 Robustness Checks

VARIABLES	(1) Mean score	(2) Median score	(3) Minimum score	(4) Maximum score	(5) Score range	(6) Female	(7) Han ethnic group	(8) Rural hukou	(9) Poor county	(10) *Gaokao* repeater
A. Meta-major Intensity										
Meta-major	0.002	0.001	0.003+	0.002	-0.001	-0.001	0.000	-0.002	0.002	0.005***
	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
B. Subsample during 2009-2018										
Meta-major	0.023	0.022	0.023	0.035	0.013	0.014	0.019	-0.039+	-0.002	0.056**
	(0.019)	(0.020)	(0.025)	(0.038)	(0.048)	(0.017)	(0.024)	(0.023)	(0.023)	(0.020)
C. Subsample of Science-track students										
Meta-major	0.036	0.032	0.051+	0.039	-0.012	0.007	0.011	-0.037+	0.014	0.059**
	(0.023)	(0.023)	(0.029)	(0.031)	(0.027)	(0.017)	(0.022)	(0.022)	(0.022)	(0.019)
D. 5 Years Prior and Post the Reform										
Meta-major	0.041*	0.042*	0.028	0.052	0.025	0.004	0.016	-0.038+	-0.018	0.032*
	(0.017)	(0.018)	(0.028)	(0.032)	(0.045)	(0.017)	(0.022)	(0.020)	(0.021)	(0.015)
E. Institutional level student composition										
Meta-major	0.022	0.026	0.002	0.041*	0.039+	-0.017	0.023+	-0.035*	0.040*	0.053***
	(0.018)	(0.019)	(0.023)	(0.020)	(0.023)	(0.013)	(0.013)	(0.016)	(0.016)	(0.014)
F. Adding College Linear Time Trend										
Meta-major	0.032+	0.031+	0.040	0.036	-0.003	0.036+	-0.010	-0.014	-0.032+	0.001
	(0.017)	(0.016)	(0.025)	(0.038)	(0.041)	(0.021)	(0.024)	(0.020)	(0.017)	(0.014)
Observations	35,487	35,487	35,487	35,487	35,487	35,487	35,487	35,487	35,487	35,487

College-major FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Notes. All regressions control for college-major and year fixed effects. Standard errors in parentheses are clustered at the university level. ***, **, *, and + indicate statistical significance levels of 0.001, 0.01, 0.05 and 0.10, respectively.

Next, I conduct an individual-level analysis. The identification strategy is the same as in Section 3.4 but with individual-level dependent variables, including individual students' standardized *Gaokao* score, gender, ethnicity, hukou status, type of county of origin, and the repeat status.

Table 3.4 show that the results confirm the institutional-level analysis above. Similarly, there is a marginally significant increase in the standardized scores of students, mainly coming from the first year of the meta-major conduction. The estimates of other students' characteristics replicate those from the previous section.

Table 3.4 Effects of Meta-Major Reform on Student Composition (Individual-Level Analysis)

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	*Gaokao* score	Female	Han ethnic group	Rural hukou	Poor county	*Gaokao* repeater
Meta-major	0.044*	0.003	0.006	-0.030	0.020	0.064***
	(0.022)	(0.016)	(0.022)	(0.022)	(0.022)	(0.019)
Constant	1.477***	0.488***	0.729***	0.433***	0.228***	0.230***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	120,576	120,576	120,576	120,576	120,576	120,576
College-major FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES

Notes. All regressions control for college-major and year fixed effects. Standard errors in parentheses are clustered at the university level. ***, **, *, and + indicate statistical significance levels of 0.001, 0.01, 0.05 and 0.10, respectively.

Finally, following the recent burgeoning innovative methods of DID, I use the estimation procedures allowing for the dynamic and heterogeneous treatment effects driven by variations in the reform's timing (Callaway & Sant'Anna, 2020; Chaisemartin & D'Haultfoeuille, 2020; Roth et al., 2022). When staggered adoption and heterogeneous effects exist, the classical two-way fixed effects may give misleading estimates. The comparison between the newly treated units and the already treated units could be wrong, which is usually referred to as the “forbidden” comparison (Goodman-Bacon, 2021). The comparisons lead to negative weighting problems and may give opposite treatment effects (Roth et al., 2022). To address this problem, Callaway & Sant’Anna (2020) only uses the never-treated or not-yet treated as control, and Sun & Abraham (2021) use the last-to-be-treated units as the comparison. Under the setting of staggered treatment adoption, these new methods give estimations that are robust to heterogeneous treatment effects across units and over time. I replicate the analyses using these methods and the results are shown in Appendix B. The figures indicate that the main results are robust to different estimations. Overall, the student composition does not change significantly. The share of repeaters remains the same with an increase after 5 years of the reform. No linear time trends of student composition are visible based on these estimators.

Heterogeneity

In this section, the heterogeneity of the treatment effects is investigated by interacting the treatment indicator with the selectivity of university and the major category. Students consider the characteristics of specific universities and majors in real decision-making, which may result in the impacts of the reform at different types of institutions or of different majors varying.

The universities in China are stratified by tiers, including Project-985, Project-211, provincial and local colleges and vocational colleges. I utilize the Simin ranking, which is constructed based on the most recent admission scores of each institution, to obtain the list of the top 10 universities in China.[26] The results presented in Table 3.5 indicate that the aggregate effects are masked by the substantial heterogeneity in the type of institutions. The mean, median, and minimum scores increase significantly at non-elite universities, and the difference in the effect of meta-major across different institution types is significant in the minimum score. Additionally, the score ranges change in different directions at universities with different selectivity levels, and this difference is statistically significant. Next, the effects of meta-major on student characteristics are also analyzed. I find that the share of ethnic minority students, students from poor counties and repeater increase significantly at elite universities.

[26] The top 10 universities are: Peking University, Tsinghua University, University of Science and Technology of China, Fudan University, Shanghai Jiaotong University, Zhejiang University, Nanjing University, Renmin University of China, University of Chinese Academy of Sciences, and Xi'an Jiaotong University.

Table 3.5 Heterogeneity in the Effects of Meta-Major Reform on Student Composition by Institution Type (Top 10 Universities)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Mean score		Median score		Minimum score		Maximum score		Score range	
VARIABLES	Top10=1	Top10=0	Top10=1	Top10=0	Top10=1	Top10=0	Top10=1	Top10=0	Top10=1	Top10=0
Meta-major	0.050*	0.009	0.040+	0.013	0.087***	-0.012	0.052	0.017	-0.034	0.030
	(0.020)	(0.037)	(0.022)	(0.040)	(0.024)	(0.039)	(0.036)	(0.039)	(0.034)	(0.024)
Meta-major # Top10	-0.041	0.041	-0.027	0.027	-0.099*	0.099*	-0.035	0.035	0.064+	-0.064+
	(0.041)	(0.041)	(0.045)	(0.045)	(0.044)	(0.044)	(0.049)	(0.049)	(0.034)	(0.034)
Observations	35,487	35,487	35,487	35,487	35,487	35,487	35,487	35,487	35,487	35,487
College-major FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

(cont'd)

	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
	Female		Han ethnic group		Rural hukou		Poor county		*Gaokao* repeater	
VARIABLES	Top10=1	Top10=0	Top10=1	Top10=0	Top10=1	Top10=0	Top10=1	Top10=0	Top10=1	Top10=0
Meta-major	0.010	-0.006	0.045+	-0.049***	-0.056+	0.005	-0.019	0.073**	0.021	0.127***
	(0.021)	(0.019)	(0.026)	(0.013)	(0.029)	(0.020)	(0.021)	(0.025)	(0.022)	(0.017)
Meta-major # Top10	-0.016	0.016	-0.094***	0.094***	0.062+	-0.062+	0.092**	-0.092**	0.106***	-0.106***
	(0.027)	(0.027)	(0.027)	(0.027)	(0.034)	(0.034)	(0.032)	(0.032)	(0.027)	(0.027)
Observations	35,487	35,487	35,487	35,487	35,487	35,487	35,487	35,487	35,487	35,487
College-major FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Notes. This table reports the results of the two-way fixed effects model after adding the interaction term between the indicators of meta-major and institutional selectivity, i.e., whether the institution is a top-10 university. For each outcome, the first column (e.g., Column 1) shows the results when the indicator of top 10 university equals 1 (top 10=0 as the reference group), while the second (e.g., Column 2) shows the results when the indicator of top 10 equals 0 (top 10=1 as the reference group). Therefore, the coefficient of meta-major in the first column represents the effect of meta-major for non-top 10 universities, while the coefficient of meta-major in the second column represents the effect for top 10 universities. And the coefficient of the interaction terms represents the difference in the effects across university selectivity. All regressions control for college-major and year fixed effects. Standard errors in parentheses are clustered at the university level. ***, **, *, and + indicate statistical significance levels of 0.001, 0.01, 0.05 and 0.10, respectively.

In terms of major, I define the "hot" or advantaged STEM majors are fields of study attached with high wage premiums in the Chinese context, including majors related to computer engineering, computer science, information technology, software engineering, and artificial intelligence. The admission scores only rise significantly in non-advantaged majors, while the effects on students' gender, ethnicity, and background are similar across different major types (see Table 3.6)

Table 3.6 Heterogeneity in the Effects of Meta-Major Reform on Student Composition by Major Category (Advantaged STEM Majors)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Mean score		Median score		Minimum score		Maximum score		Score range	
VARIABLES	AS=1	AS=0	AS=1	AS=0	AS=1	AS=0	AS=1	AS=0	AS=1	AS=0
Meta-major	0.042*	-0.026	0.037+	-0.025	0.054+	-0.004	0.051+	-0.056	-0.003	-0.053+
	(0.020)	(0.036)	(0.021)	(0.040)	(0.029)	(0.034)	(0.029)	(0.039)	(0.030)	(0.028)
Meta-major # Advantaged STEM	-0.068*	0.068*	-0.062+	0.062+	-0.057	0.057	-0.107**	0.107**	-0.050	0.050
	(0.030)	(0.030)	(0.034)	(0.034)	(0.035)	(0.035)	(0.035)	(0.035)	(0.040)	(0.040)
Observations	35,487	35,487	35,487	35,487	35,487	35,487	35,487	35,487	35,487	35,487
College-major FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

(cont'd)

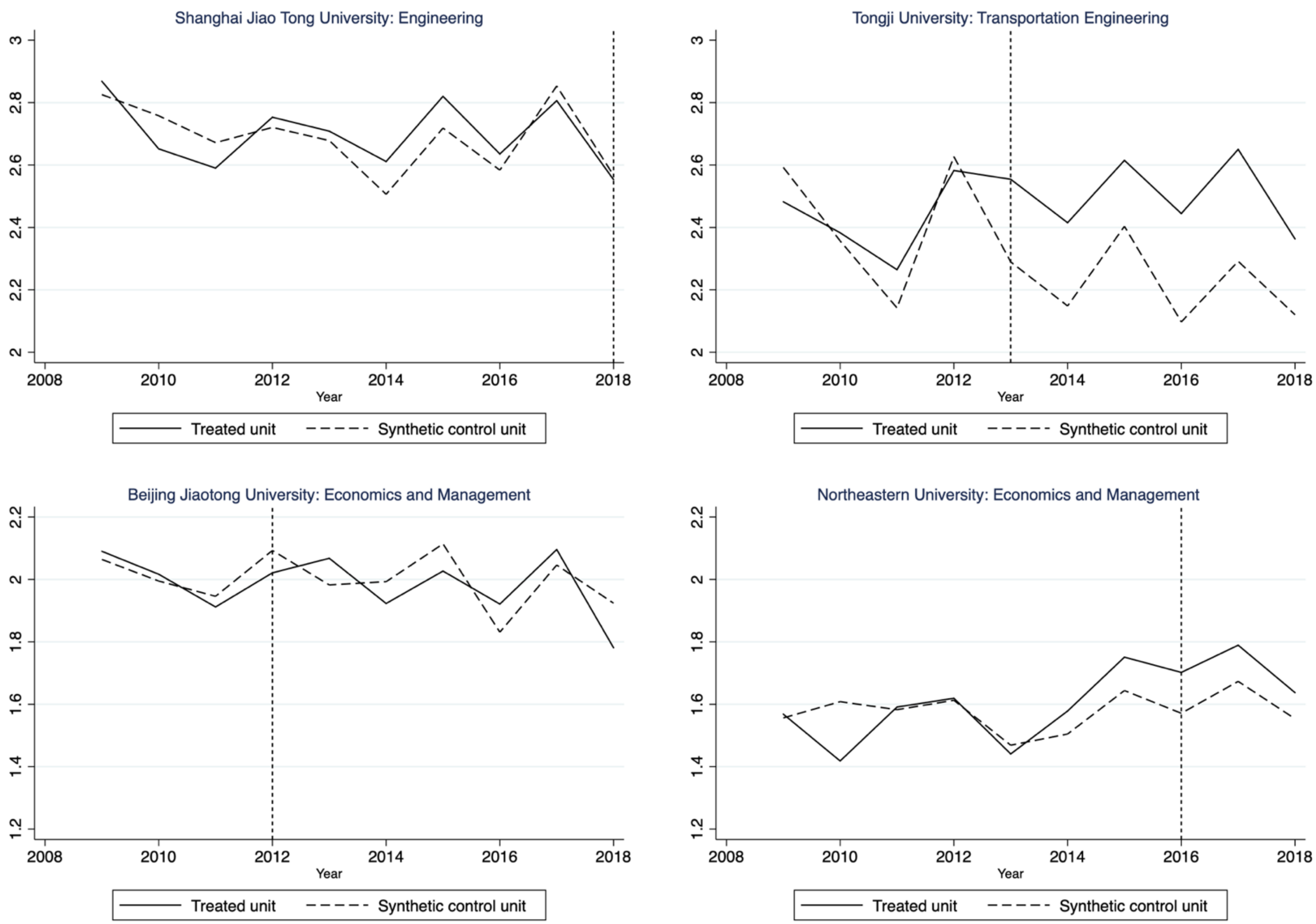
	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
	Female		Han ethnic group		Rural hukou		Poor county		*Gaokao* repeater	
VARIABLES	AS=1	AS=0	AS=1	AS=0	AS=1	AS=0	AS=1	AS=0	AS=1	AS=0
Meta-major	-0.004	0.063	0.010	-0.014	-0.039	0.020	0.022	-0.009	0.064**	0.064*
	(0.017)	(0.041)	(0.023)	(0.038)	(0.024)	(0.028)	(0.023)	(0.034)	(0.020)	(0.025)
Meta-major # Advantaged STEM	0.067	-0.067	-0.024	0.024	0.058	-0.058	-0.030	0.030	0.000	-0.000
	(0.043)	(0.043)	(0.039)	(0.039)	(0.037)	(0.037)	(0.034)	(0.034)	(0.025)	(0.025)
Observations	35,487	35,487	35,487	35,487	35,487	35,487	35,487	35,487	35,487	35,487
College-major FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Notes. This table reports the results of the two-way fixed effects model after adding the interaction term between the indicators of meta-major and the popularity of majors, i.e., whether the major is an advantaged STEM major. For each outcome, the first column (e.g., Column 1) shows the results when the indicator of advantaged STEM major equals 1 (advantaged STEM major =0 as the reference group), while the second (e.g., Column 2) shows the results when the indicator of advantaged STEM major equals 0 (advantaged STEM major =1 as the reference group). Therefore, the coefficient of meta-major in the first column represents the effect of meta-major for non-advantaged STEM majors, while the coefficient of meta-major in the second column represents the effect for advantaged STEM majors. And the coefficient of the interaction terms represents the difference in the effects across majors. All regressions control for college-major and year fixed effects. Standard errors in parentheses are clustered at the university level. ***, **, *, and + indicate statistical significance levels of 0.001, 0.01, 0.05 and 0.10, respectively.

Finally, to investigate how the student composition in a specific meta-major evolves over time, I construct a synthetic control major category for each meta-major by the pool of all the other control majors (traditional specific college-major) (Abadie et al. 2010). The method assigns weights to the control majors such that the squared difference in terms of the outcome predictors between the treatment and its synthetic control in the pre-treatment period is minimized, then the effect of meta major reform is estimated by comparing the outcomes between the treatment and its synthetic control in the post-treatment period. The variables used as predictors in the construction of synthetic controls include the average and median admission scores and the admission quota.

Figure 3.5 shows the trends of average admission score of the meta majors and their synthetic control of four example meta-majors. Although the figure is illustrative, it does not tell us whether there is a statistically significant change in the admission scores in meta majors compared to synthetic control majors in the post-reform period (Ersoy, 2020). There is a clear increase in the mean score in some majors, for example, economics and management at Northeastern University and transportation engineering at Tongji University, compared to their synthetic control. Some majors do not show much change after the reform, for example, economics and management at Beijing Jiaotong University and engineering at Shanghai Jiao Tong University. By comparing these two groups of meta-majors, I find that the former majors basically only contain a set of majors that are highly relevant with a clear focus on the field of study, while the latter are usually large collections of many weakly correlated majors and lack a clear focus. While the transportation engineering at Tongji University only includes transportation engineering and logistics engineering, engineering at Shanghai Jiao Tong University covers almost all engineering majors, including mechanical engineering, electronic information science and technology, electrical information engineering, materials science and engineering, energy, and power engineering, etc. Therefore, the impacts of the meta-major reform are relevant to how the majors are constructed.

Figure 3.5 Trends in Average Admission Score (Synthetic Control method)



Notes. The figures show the mean scores of the four meta-majors and their synthetic controls. The vertical dashed lines denote the year of the reform.

Discussion and Conclusion

The paper contributes to the debate over the major choice mechanism designs by providing one of the first empirical evidence on the how a university-level major reform, i.e., the transition from jointly college-major choice to sequentially college-then-major choice, could impact choice behaviors from the perspective of students and the characteristics of admitted students from the institutional side in a centralized higher education system.

Overall, the meta-major reform does not impact students' ability distribution and demographic characteristics within college-majors. The admission scores rise in the first year of the implementation of meta-major but do not change substantially in the long term. The instant effect implies that the new major setting attracted high-achieving students when the policy just came out. However, the effects faded out over time. One potential explanation is that students gradually learn more about regulations, training mode and the real quality of a meta-major and also begin to realize the potential risks attached to it. Additionally, although meta-major simplifies students' initial choice and allows learning before their final major declaration, it also adds to the uncertainty of students' major choices as the related information is usually unavailable or imperfect. Finally, the consequences vary across students, for example, students with different preferences and prior knowledge probably respond to the meta-major differently. More discussions about the mechanisms will be provided in Chapter 4.

However, the aggregate null effects are masked by the substantial heterogeneity across institutions and majors. Meta-major reform disproportionately increases the student quality at non-elite universities, especially in terms of the minimum admission scores. Similarly, the admission scores in non-advantaged majors also rise after the conduction of meta-major. These findings imply that clustering traditional specific majors into a larger meta-major is potentially an effective way of attracting more talented students to non-elite colleges, and the student quality in non-advantaged majors also gets improved when these majors are combined with other popular majors and recruit students under a broad meta-major category. The findings suggest that for the policymakers, i.e., the universities, the meta-major shows the potential of increasing student quality, especially for those that are not ranked at the very top of the higher education hierarchy. The meta-major increases the “competency” of institutions in attracting talented students since it integrates the advantages of previously separated disciplines and departments and creates “super” majors. The policy could be eye-catching for candidates and possibly inspire them to choose the college-major even though the college is not at the very top. Another important implication of the combination of various majors is that the major classification within meta-major may be effective in improving the candidate pool, especially for majors that are usually being attached with relatively low prospects by students. To get access to some popular majors, students have to first enter the meta-major. The admission scores of other majors under the same meta-major could be improved even if they are not the target of most students.

Additionally, the meta-major reform could disproportionately benefit some traditional under-representative students in higher education, such as ethnic minority students and students from poor counties, by increasing their enrollment at elite universities. Many key universities adopt the policy of preferential admission for students from ethnic minorities and poor counties. And meta-majors are usually open to those students in order to provide them with a wide range of major opportunities, such as the special college enrollment plan for rural students in the science meta-major at Fudan University and engineering meta-major at Xi'an Jiaotong University. The policy may have the largest effects on disadvantaged students since they are usually the group of students who are faced with the problems of incomplete information and behavioral barrier. And the chance to explore their interests and gaining more knowledge of majors could be extremely beneficial for them to make better college major choices (more discussions will be provided in Chapter 4). As the distribution of education resources is still unbalanced across different regions in China, the policy helps the promotion of education equity and inclusive practices.

Appendix A. Event Study Results

Table A. 3.1 Effects of Meta-Major Reform on Student Composition (Event study)

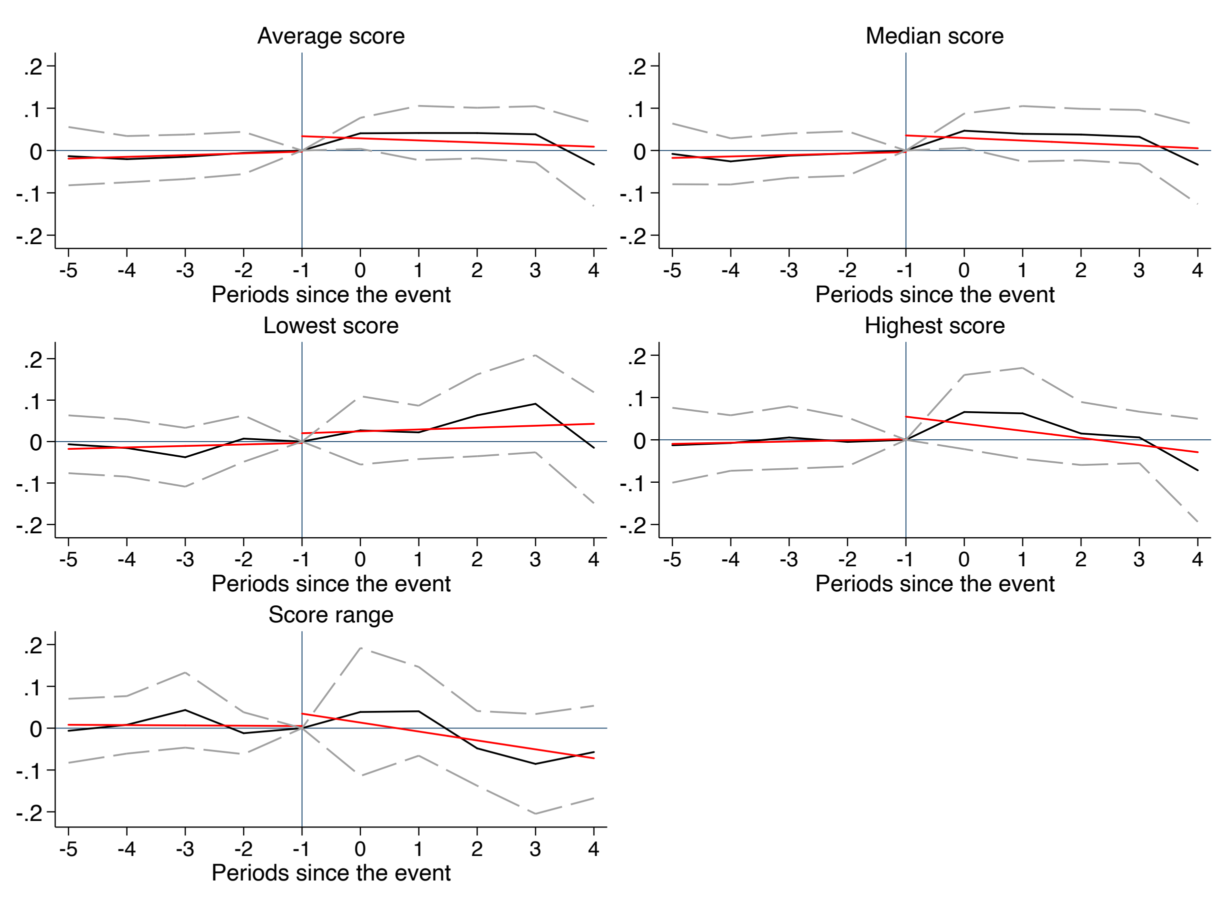
VARIABLES	(1) Mean score	(2) Median score	(3) Minimum score	(4) Maximum score	(5) Score range	(6) Female	(7) Han ethnic group	(8) Rural hukou	(9) Poor county	(10) *Gaokao* repeater
5 years prior to the reform	-0.002	0.002	0.006	-0.006	-0.012	0.018	0.017	0.055	0.020	-0.028
	(0.029)	(0.032)	(0.030)	(0.040)	(0.044)	(0.024)	(0.030)	(0.038)	(0.034)	(0.021)
4 years prior to the reform	-0.010	-0.017	-0.005	0.000	0.006	0.047	0.018	0.024	0.020	-0.033
	(0.024)	(0.024)	(0.036)	(0.028)	(0.040)	(0.029)	(0.037)	(0.030)	(0.037)	(0.020)
3 years prior to the reform	-0.005	-0.003	-0.028	0.012	0.041	-0.067*	0.038	0.048+	0.025	-0.004
	(0.023)	(0.024)	(0.038)	(0.034)	(0.052)	(0.031)	(0.030)	(0.029)	(0.023)	(0.025)
2 years prior to the reform	0.001	-0.003	0.015	-0.001	-0.016	-0.032	0.036	0.021	-0.003	0.011
	(0.024)	(0.026)	(0.030)	(0.027)	(0.028)	(0.032)	(0.031)	(0.023)	(0.027)	(0.021)
0 years post the reform	0.040*	0.043*	0.029	0.066+	0.037	-0.013	0.033	-0.022	0.002	0.003
	(0.019)	(0.021)	(0.035)	(0.036)	(0.059)	(0.023)	(0.035)	(0.020)	(0.023)	(0.018)
1 year post the reform	0.041	0.034	0.023	0.066	0.043	-0.013	-0.013	-0.010	-0.008	0.036
	(0.036)	(0.039)	(0.042)	(0.048)	(0.036)	(0.033)	(0.038)	(0.036)	(0.031)	(0.026)
2 years post the reform	0.043	0.038	0.040	0.027	-0.013	0.039	0.024	0.001	-0.029	0.040
	(0.031)	(0.033)	(0.041)	(0.037)	(0.035)	(0.029)	(0.034)	(0.039)	(0.034)	(0.029)
3 years post the reform	0.043	0.035	0.062	0.024	-0.038	0.003	0.053	-0.019	-0.047	0.033
	(0.029)	(0.031)	(0.046)	(0.031)	(0.050)	(0.063)	(0.064)	(0.052)	(0.050)	(0.028)
4 years post the reform	-0.052	-0.053	-0.076	-0.064	0.012	0.012	-0.101*	-0.028	-0.005	0.084**
	(0.056)	(0.053)	(0.089)	(0.059)	(0.062)	(0.040)	(0.048)	(0.060)	(0.047)	(0.028)

Constant	1.450***	1.455***	1.228***	1.678***	0.450***	0.487***	0.733***	0.434***	0.235***	0.238***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)
Observations	35,487	35,487	35,487	35,487	35,487	35,487	35,487	35,487	35,487	35,487
College-major FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Notes. All regressions control for college-major and year fixed effects. Standard errors in parentheses are clustered at the university level. The reference year is one year prior to the reform. ***, ** and * indicate statistical significance levels of 0.01, 0.05 and 0.10, respectively.

Appendix B. Robustness Check

Figure B. 3.1 Event Study Results after Adding the College Linear Trend



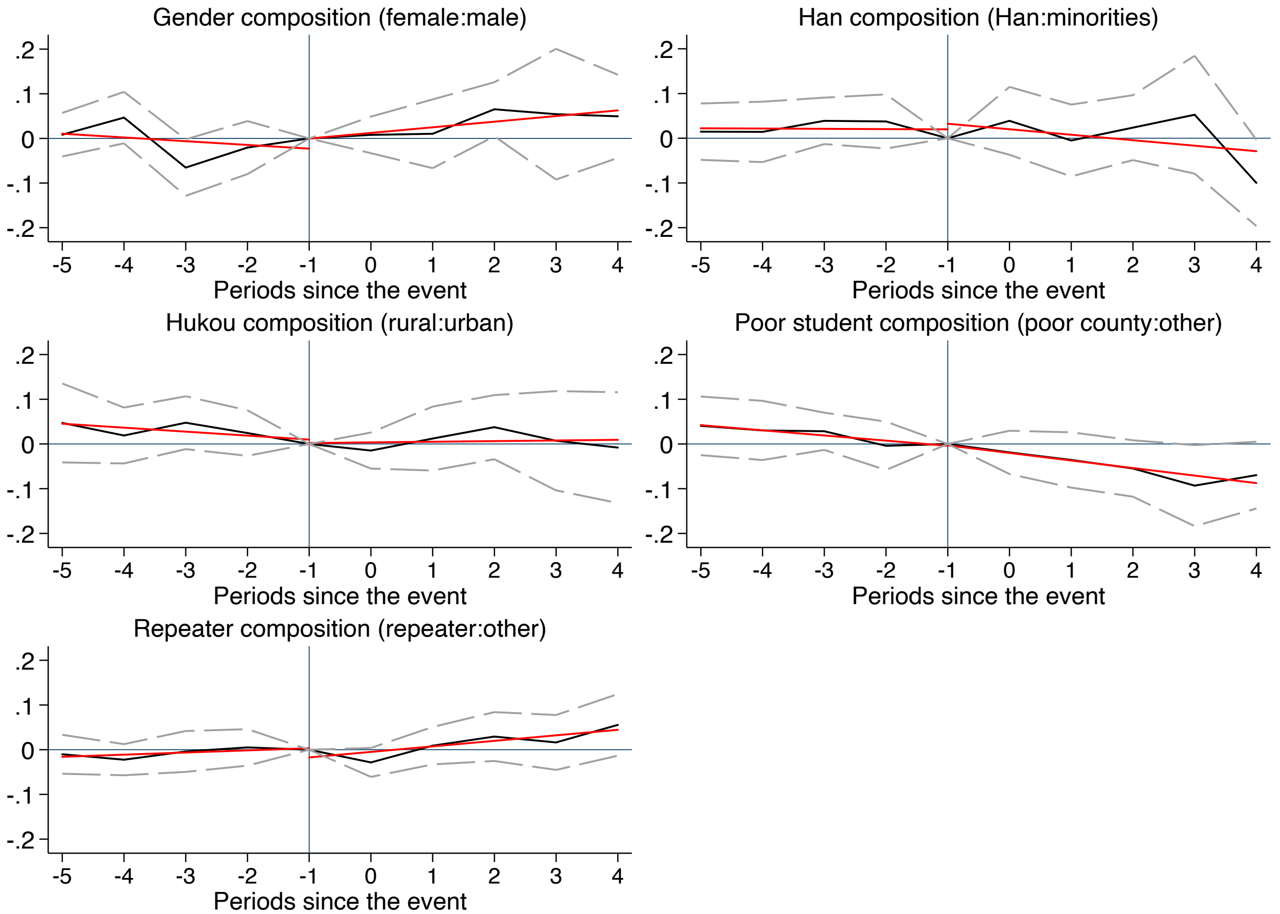
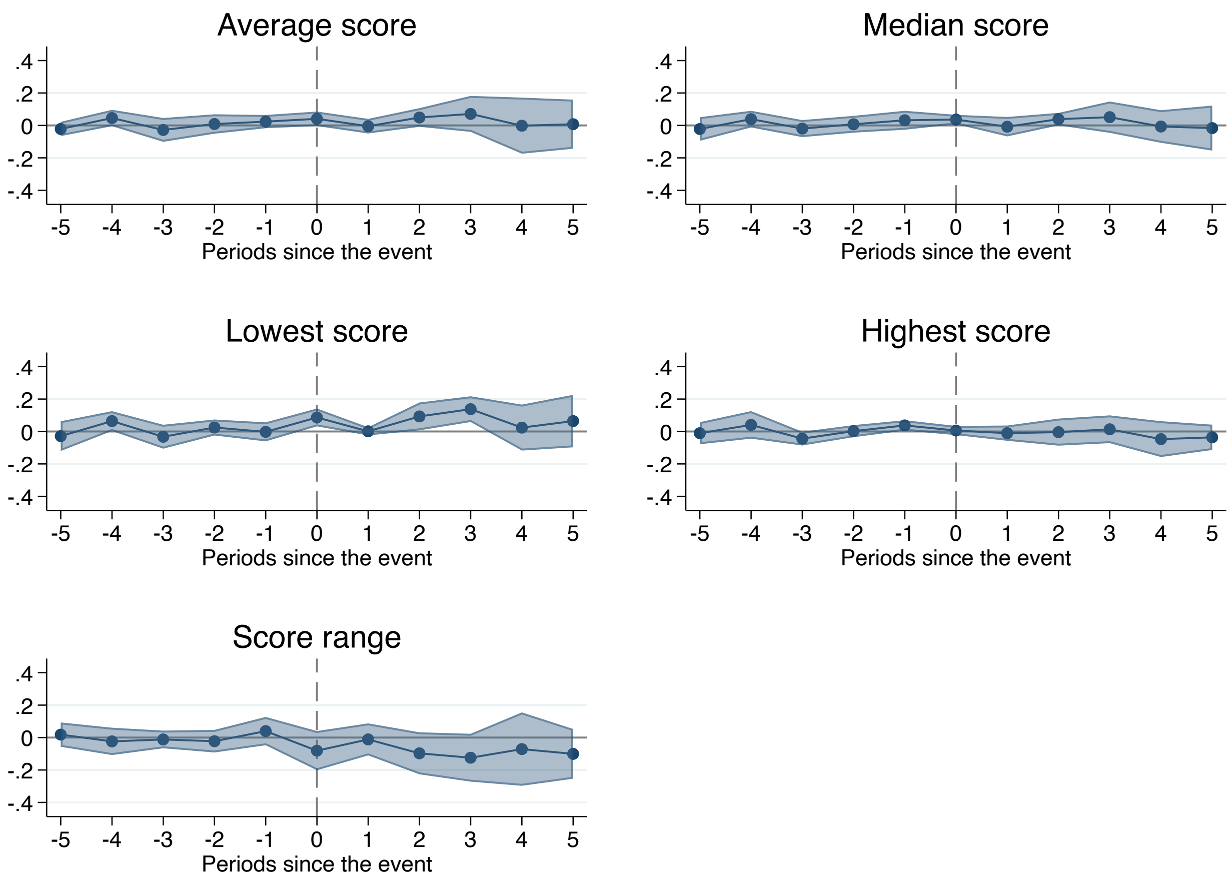

Gender composition (female:male)
Han composition (Han:minorities)
Hukou composition (rural:urban)
Poor student composition (poor county:other)
Repeater composition (repeater:other)
.2
.1
0
-.1
-.2
-5 -4 -3 -2 -1 0 1 2 3 4
Periods since the event

Figure B. 3.2 Event Study Results Based on Chaisemartin & D'Haultfoeuille (2020)'s Estimator



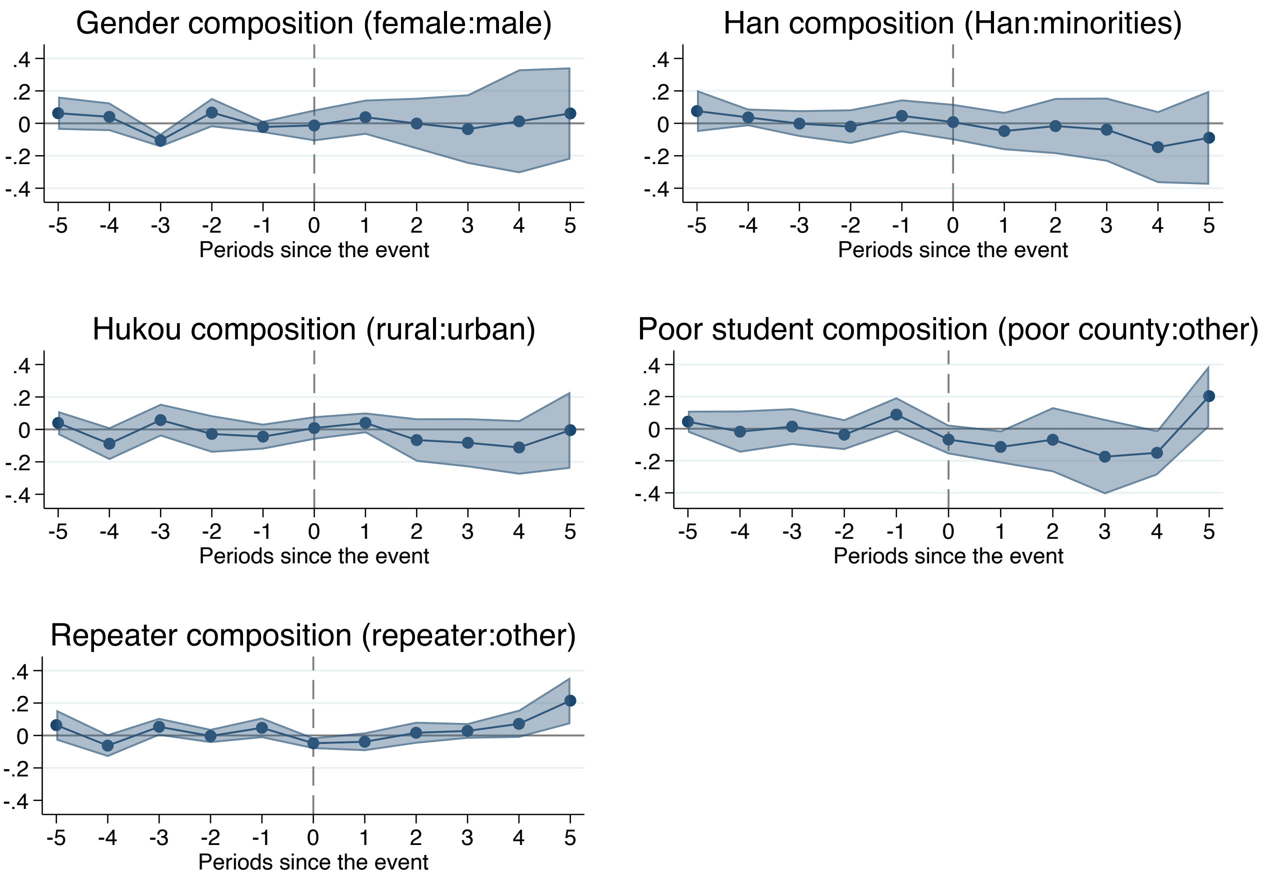
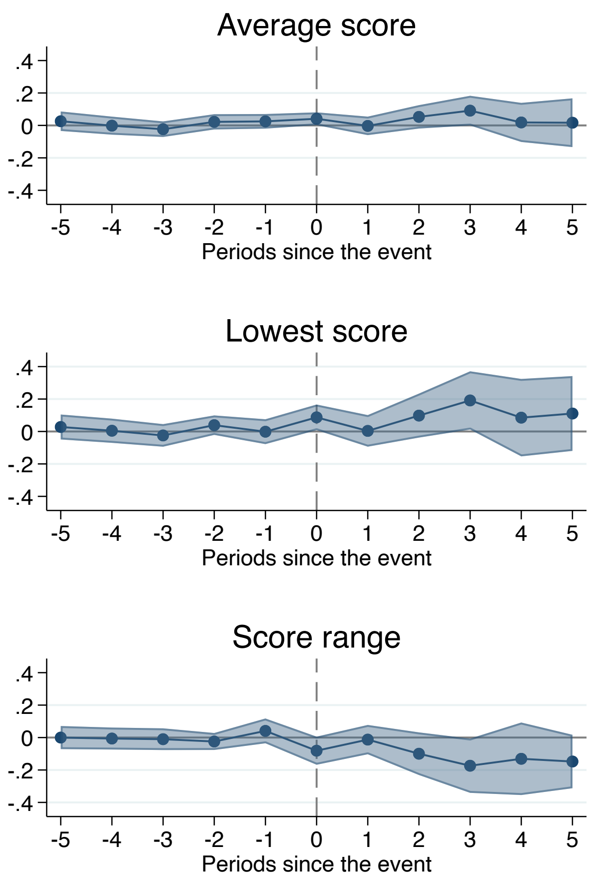
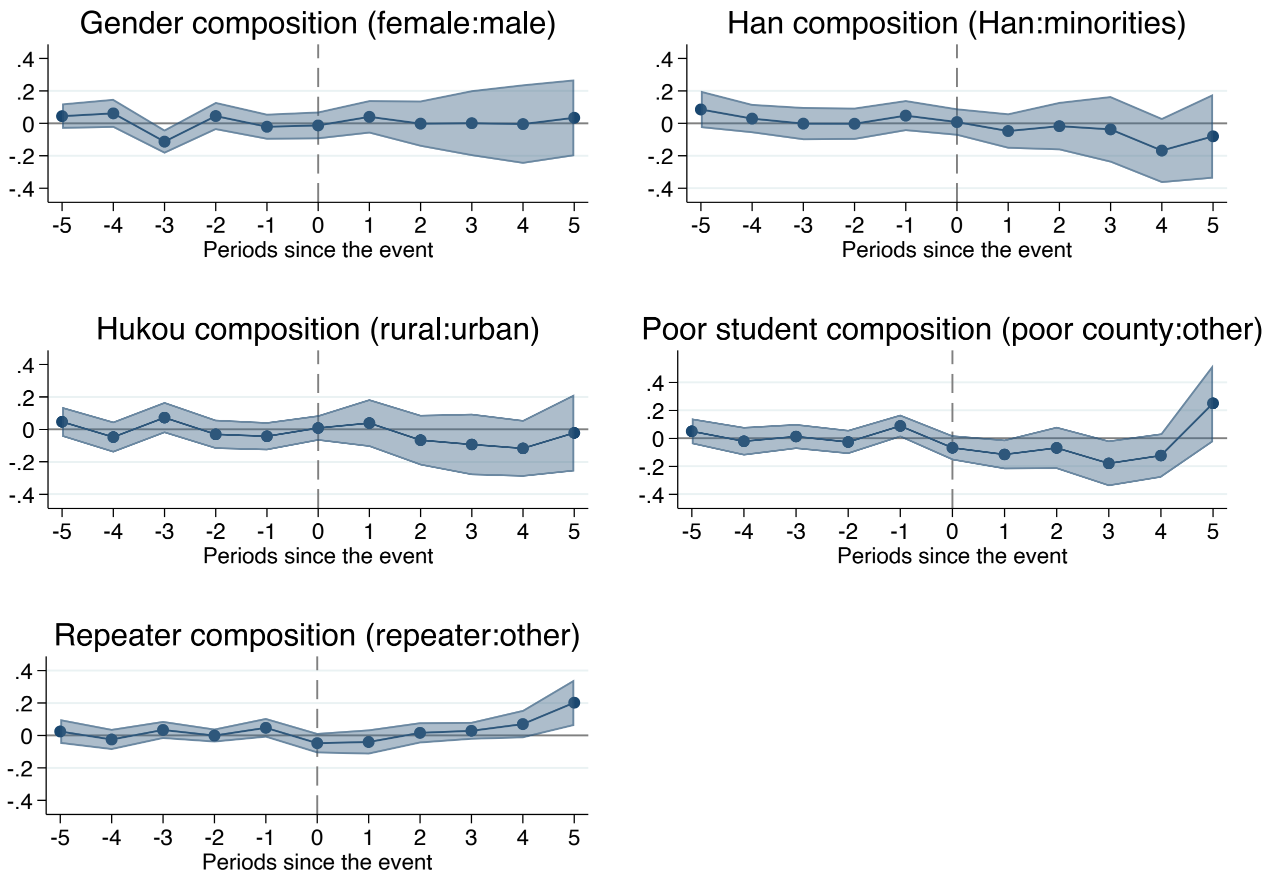

Gender composition (female:male)
.4
.2
0
-.2
-.4
-5 -4 -3 -2 -1 0 1 2 3 4 5
Periods since the event
Han composition (Han:minorities)
.4
.2
0
-.2
-.4
-5 -4 -3 -2 -1 0 1 2 3 4 5
Periods since the event
Hukou composition (rural:urban)
.4
.2
0
-.2
-.4
-5 -4 -3 -2 -1 0 1 2 3 4 5
Periods since the event
Poor student composition (poor county:other)
.4
.2
0
-.2
-.4
-5 -4 -3 -2 -1 0 1 2 3 4 5
Periods since the event
Repeater composition (repeater:other)
.4
.2
0
-.2
-.4
-5 -4 -3 -2 -1 0 1 2 3 4 5
Periods since the event

Figure B. 3.3 Event Study Results Based on Callaway & Sant'Anna (2020)'s Estimator




Gender composition (female:male)
Han composition (Han:minorities)
Hukou composition (rural:urban)
Poor student composition (poor county:other)
Repeater composition (repeater:other)
.4
.2
0
-.2
-.4
-5 -4 -3 -2 -1 0 1 2 3 4 5
Periods since the event

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Chapter 4 College-Major Choice to College-then-Major Choice Reform: Experimental Evidence on Student College Major Choice Behavior

Abstract

One of the most important mechanism design policies in college admissions is for students to choose a college major sequentially (college-then-major choice) or jointly (college-major choice). However, how students behaviorally respond to these policies is unclear. In the context of the Chinese meta-major reforms, the paper provides one of the first experimental evidence on the heterogeneous impacts of a transition from college-major to college-then-major choice on students' willingness to apply, with a special focus on the role of information. In a randomized informational experiment with a nationwide sample of high school graduates, the results show that providing information on the benefits of a meta-major significantly increased students' willingness to apply; however, information about specific majors and assignment mechanisms has insignificant impacts. The information mostly affects the preference of students who come from disadvantaged backgrounds, lack accurate information or clear major preferences, or are risk-loving.

Keywords: College major choice, Survey experiments, Insufficient information

Introduction

College major choice, which affects individuals' long-term career choices and skill compositions in the workforce, has been brought to the forefront of the global higher education policy agenda (Altonji et al., 2012, 2016; Patnaik et al., 2020). One of the most important mechanism design policies in college admissions is for students to choose a college major sequentially (college-then-major choice) or jointly (college-major choice). Unlike the United States and Canada, which allow students to declare a major after they enroll at colleges, many countries employ college-major admissions policies that require students to choose a college-major pair jointly when they submit their applications (Bordon & Fu, 2015; Kirkeboen et al., 2016; Krussig & Neilson, 2021; Machado & Szerman, 2021; Meyer et al., 2021).[27] The college-major choice provides students with more specialized training upon college enrollment and helps them confer degrees quickly and efficiently. Alternatively, the college-then-major choice allows students to explore and develop their major-specific interests, with a low switching cost. Which policy is better for a targeted group of students depends on student sorting, which is relevant to students' academic achievement, prior major intent, risk attitudes, and application strategy; however, little is known from the literature about how students would behaviorally respond to the two different college major choices policies.

This paper fills this gap by examining recent national reforms in college-major admissions in China, which has the world's largest centralized college matching market (Chen &

[27] In the U.S., there have recently been two distinct trends: (1) Students in most colleges can switch majors, and according to NCES data, 30% of them choose to do so (https://nces.ed.gov/pubs2018/2018434.pdf); (2) many colleges have begun to ask students to specify their intended major on their applications, pressuring students to select a major early on (related reports include: https://www.collegesolutions.com/blog-articles/you-have-to-choose-a-major-sooner-than-you-think; https://hechingerreport.org/some-colleges-ease-up-on-pushing-undergrads-into-picking-majors-right-away/).

Kesten, 2017). The reform of allowing a subset of colleges to switch from college-major admissions to college-then-major admissions was recently started in China. The core of these university-level reforms is the implementation of meta-majors, which cluster relevant academic majors into a larger cohesive bucket (e.g., a science meta-major includes all science-related majors). These meta-major reforms provide a unique opportunity to empirically study students' preferences for different college major choice mechanisms.

Recent literature shows that delaying specialization in a college-then-major choice mechanism is conducive in helping students discover their comparative advantage. Furthermore, it increases student-major match quality and student welfare (Bordon & Fu, 2015). A meta-major provides a wide range of major and career opportunities and simplifies major choices when applying to colleges. However, students face significant uncertainties in the final major declaration and risks of being assigned to less-preferred majors during college. Therefore, the effects of meta major are ambiguous, depending on how students respond to different components and characteristics of the reform. Additionally, students may have incomplete information or biased beliefs about potential benefits and risks associated with meta majors (Patnaik et al., 2020). Their major choices can be largely affected by what information is available and how options are structured in the reform.

The study provides one of the first experimental evidence on the heterogeneous impacts of college-major to college-then-major reform on students' college-major choice preferences. By integrating quantitative and qualitative evidence, the study is guided by the following research question:

1) To what extent do students respond differently to various kinds of information on meta-majors?

A randomized informational experiment is conducted to identify the impact of meta-major information on students' major-choice decisions. The experiment was designed to test the three most frequently mentioned characteristics of the meta-major reform: (1) the specific majors offered by the meta-majors, (2) the benefits of the meta-majors, and (3) the assignment mechanisms and corresponding risks of major declarations in the meta-majors. When making their college major choices, students are centralized and provided with information on the specific majors offered by each meta-major; however, they may have information frictions in understanding the benefits and the assignment mechanisms (Arcidiacono et al., 2016).

We collaborated with the Chinese Society of Educational Development Strategy—which falls under the aegis of the Ministry of Education of China—and implemented the experiment via an online survey with a large, nationwide sample of high school graduates of 2020 (N = 11,424). The survey participants were asked to declare their willingness to choose the meta-majors (versus the traditional college majors) after being randomly presented with information in one of the three treatment groups or a control group without additional information. Information regarding the meta-majors' benefits statistically and significantly increased students' willingness to apply for them by approximately six percentage points. This was a nine percent increase from the control mean of 70%. Information about specific majors and risks had statistically insignificant effects on their willingness to apply. Moreover, students had heterogeneous beliefs on the different aspects of a meta-major, which could affect their major choice: All three types of information had a larger impact on those students who were (1) from disadvantaged backgrounds, (2) had limited access to college-major choice information and guidance, (3) did not have strong preferences for specific majors, and (4) who were risk-loving.

Building on the qualitative evidence, we provide interpretations for the experimental results. We investigated students' revealed preferences for meta-majors using qualitative data from one of the largest Chinese online discussion boards and supplemental focus group interviews. The analyses show that meta-major reform had sparked heterogeneous beliefs among students, and they were concerned about various aspects of the meta majors. This includes, but is not limited to, major and course settings, cross-disciplinary training, study burden, assignment mechanisms, and education equity. Students have different opinions and attitudes toward this new meta-major setting, which may be correlated with their information exposure driven by their socioeconomic background.

Our paper contributes new empirical evidence on the ongoing worldwide policy reforms that are alternating between college-major and college-then-major choices. For example, some US colleges ask students to make a choice between undergraduate colleges or meta-majors. [28] Students in different contexts are all confronted with the problems of information friction.[29] We extend the literature by using survey and text data, integrating a variety of quantitative (experimental) and qualitative methods, and providing one of the first pieces of empirical evidence on different major-choice mechanisms. The meta-major, as an important university-level reform that switches from college-major to college-then-major admissions, greatly affects students' schooling choices and subsequent careers. However, in the context of the meta-major

[28] For example, students have to apply to one college directly at universities like Cornell and the University of Illinois at Urbana/Champaign. Students' final major options will be limited to the selected college, and the internal transfer within the university could be difficult (https://hechingerreport.org/some-colleges-ease-up-on-pushing-undergrads-into-picking-majors-right-away/). Another example is that at the Georgia State University, incoming students are required to enroll in one of the seven meta majors in the fields of science, technology, engineering, math, business, arts, humanities, policy, health, education, and social sciences. https://success.gsu.edu/initiatives/meta-majors/
[29] For example, the information on major selection restrictions may not be found on the admission website or not be online anywhere (https://hechingerreport.org/some-colleges-ease-up-on-pushing-undergrads-into-picking-majors-right-away/).

reforms in China, students were not given sufficient information about how their final major would be determined in a meta-major. Therefore, they faced increased uncertainty after the reform. We use a large-scale survey informational experiment to test how varied information would affect students' decision-making. This provides pivotal implications for higher-education institutions reforming college majors to attract more talented students, high school and college counselors providing guidance and assistance to high-school graduates, and individual students making one of the most important decisions of their lives.

Related Literature

There is little direct evidence on student behavioral response to the meta major reform, so this section starts with an introduction of college/college major choice model, and then a review of the effects of information experiment/intervention/nudge on student choice. The choice model is highly relevant to the change of specialization time in the reform from college-major choice to college-then-major choice. The role of information is the main focus of the study, and an information intervention will be used to identify how students respond to various components of meta major reform. Relative literature on nudges in education is helpful in understanding the design and interpretation of the experiment.

Uncertainty, Learning, and the Dynamics of Major Choice

The classic decision-making theory asserts that people are aware of all available choices and have the ability to evaluate the utility of each alternative separately (Payne, 1976). Educational investment is usually modeled as a static optimization problem, in which people choose the level of lifetime utility-maximizing with certainty (Stange, 2012). Many early works regarded the choice of university as a static decision with almost no uncertainty. The process whereby educational intentions are converted into actual educational selection is typically treated as a black box. However, a more realistic educational selection process should incorporate uncertainty about future graduation and post-graduation outcomes, as well as learning about one's own abilities and the characteristics of certain options (Arcidiacono et al., 2016; Stinebrickner & Stinebrickner, 2012; Gong et al., 2020; Patnaik et al., 2020). Uncertainty and option value are central features of educational investment (Stange, 2012). In the context of college major choice, students may have incomplete information or biased beliefs about the scope of a field, the match quality of a major with their interest and ability, as well as labor market returns to certain fields (Fricke et al., 2018).

More realistically, dynamic structural models permit individuals to leave or re-enter the university as a result in response to new information about the relative desirability of schooling (Stange, 2012; Altonji et al., 2012). Delaying college field specialization is informative in discovering comparative advantage and increasing match quality (Malamud, 2010; Bridet & Leighton, 2015). Learning about their fits to various majors and elimination of informational frictions before choosing one leads to an increase in average student welfare (Bordon & Fu, 2015; Bridet & Leighton, 2015; Arcidiacono et al., 2016). In contrast, mandatory specialization lowers student welfare in the form of income growth and turnover (Silos & Smith, 2015).

Heterogeneous Effects of the Information Intervention on Major Choice

Many information experiments have been conducted on students' beliefs in college major choices, such as earnings (e.g., Wiswall & Zafar, 2015; Hastings et al., 2015; Conlon, 2019), exposure to a field of study in the form of doing research paper or taking certain courses (e.g., Fricke et al., 2018). Students' expectations are substantially biased but are malleable to information - oftentimes logically updating their beliefs in response to the information provided in experiments. Simple information interventions are important for reducing uncertainty about major and outcomes and can have meaningful impacts on beliefs and major choices.

Empirical studies revealed that informational nudges have heterogeneous effects. While nudging often has positive effects, the greatest effects often arise for individuals affected most by the behavioral barriers (lack of self-control, limited attention and cognitive ability, loss aversion, default bias, self- and social-image and social norms, biased beliefs) targeted by the intervention (Damgaard & Nielsen, 2018). Behavioral interventions may be particularly effective for individuals facing economic or social scarcity (Mullainathan & Shafir, 2013). They lack accurate information and have more behavioral barrier problems, which impede them from making good decisions. Positive effects of nudges are more likely to arise for groups who lack information, for example, the information about returns to education has the largest effects on low-socioeconomic (SES) students who likely lack such information since they often have less educated or low-income parents (Damgaard & Nielsen, 2018).

Additionally, studies found that students with low SES are more likely to be affected by self-control problems, limited attention and cognitive ability, and default bias, and therefore the effects of some interventions are largest for them (Golsteyn, et al., 2014; Damgaard & Nielsen, 2018). For example, a reminder intervention sending text messages about deadlines, tasks, and information on college enrollment or financial aid application has the largest effects for low-SES students with less access to assistance from other sources and less clearly formulated plans (Castleman & Page, 2015; Bird et al., 2017). Similarly, information intervention on college major choices may have heterogeneous effects on people with different personal characteristics and/or risk preferences (Altonji, 1993; Bordon & Fu, 2015). For example, Ding et al. (2021) find that female students are less likely to be impacted by the wage information in STEM-related major applications and admissions since they are less likely to value extrinsic incentives for major choices.

Background

High school graduates likely face information frictions when considering applying to the meta majors. This section provides detailed background information on what kind of information is available to a college applicant in terms of major setting, benefits and the assignment mechanism of meta majors in a real scenario.

First, when students make their college applications, they usually use the official college application guidebook distributed by the provincial Department of Education as the primary information source. In this guidebook, students could get access to information on meta major names, the specific majors, tuition, quota, and the previous admission scores of each university. Appendix A provides an example of the information from screenshots of the guidebook. Based on the observations on and interactions with high school graduates and their parents, the official college application guidebook is usually the most important and probably the only information source for their higher education decision-marking.

Second, information on the benefits is often advertised by each college. Typically, college information sessions, recruitment materials, or social media provide such information. However, not all students could access this information, especially students from disadvantaged backgrounds, even though it was freely accessible. Some students may intentionally or unintentionally ignore or forget such information due to a lack of attention (Damgaard & Nielsen, 2020).

Finally, the major assignment mechanism is the most likely to be ignored by students. While college Admissions Prospectus including the rules of assignment is centralized provided online by the Ministry of Education, most students do not notice its existence. Moreover, the information on major assignment mechanisms is often fuzzy and difficult to understand. We conducted a comprehensive scan and review of policies for all the colleges and were not able to identify accurate assignment mechanisms for nearly all of the colleges. For example, Appendix Figure A. 4.2 presents the relevant information for a top-5 college in China: "*major assignment will be carried out within the platform and college (meta majors) based on student preference, college entrance examination scores, tests scores in college, and other regulations.*" However, nothing is mentioned about how to weigh various items and how students would be matched to different majors. Even if students read this information, they still cannot accurately predict their probabilities of being assigned to different specific majors.

Experimental Design

A field experiment was designed and implemented with Chinese high school graduates in the summer of 2020. In a survey conducted by the Chinese Society of Educational Development Strategy, we included an experimental module on students' major choice intentions. The survey also collected rich information on students' demographic characteristics, family background, high school experience, and college applications. A nationwide sample of 11,424 high school graduates from 268 schools in 28 provinces across the country completed the survey in 2020.

This sample was purposely restricted to students who participated in the National College Entrance Exam and were eligible for four-year undergraduate college admissions.

In the randomized experimental module of the survey implemented on an online survey platform, students were asked to declare their willingness to choose the meta major (vs. traditional college-majors) after being randomly presented with one of the four different types of information: (1) Control: the name of meta major; (2) T1 (major information): the specific majors offered by the meta major; (3) T2 (benefit): the specific majors offered by the meta major + the benefits of the meta major; (4) T3 (assignment mechanism): the specific majors offered by the meta major + the assignment mechanism and uncertainties of major declaration in the meta major.

The majors included in each meta major and the introductory descriptions are exactly copied from official texts in several selective colleges. That is, we compiled the variations in information from different colleges, each of which may have a proportion of the information that we presented to students. Because students in the science and humanities tracks in the National College Entrance Exam are eligible for different meta majors, we slightly differed the versions for students in the two tracks. Table 4.1 details the survey intervention components. T1 closely resembles the common information that students could get access to as discussed in the prior background section. T2 would make the benefits information more salient and increase students' interests in the meta majors. It is ambiguous whether students respond to the assignment mechanism information (T3) positively or negatively.

Table 4.1 Information Intervention Components

Group	Information	Content: Science-track	Content: Humanities-track
		Question: *Meta major is an important reform of college admission. Please indicate whether you would like to choose a science meta major or not.*	Question: *Meta major is an important reform of college admission. Please indicate whether you would like to choose a humanities meta major or not.*
Control	Name	Engineering meta major	Humanities meta major
T1: Major information	The specific majors offered by the meta major	The meta major of science includes the following specific majors: mechanical engineering, energy and power engineering, nuclear engineering and nuclear science, electronic information and electrical engineering, marine and marine engineering, materials science and engineering, biomedical engineering, chemical engineering, etc.	The meta major of humanities includes the following specific majors: Chinese, foreign languages, history, philosophy, archaeology, etc.
T2: Benefit	The specific majors offered by the meta major + the benefits of the meta major	In view of the growing importance of cross-disciplines in scientific and technological innovation, multidisciplinary intersection and integration have become the driving force of modern and future engineering technology development and innovation. The meta major is created by combining multiple departments and integrating multiple advantaged engineering disciplines. The meta major of science includes the following specific majors: mechanical engineering, energy and power engineering, nuclear engineering and nuclear science, electronic information and electrical engineering, marine and marine engineering, materials science and engineering, biomedical engineering, chemical engineering, etc.	The meta major of humanities provides basic education in humanities with a deep foundation and a wide range and cultivates high-quality compound talents who inherit the wisdom of ancient and modern sages, lead the trend of the spirit of the times, and possess international vision, innovation awareness and strong professional skills. The meta major of humanities includes the following specific majors: Chinese, foreign languages, history, philosophy, archaeology, etc.
T3: Assignment mechanism	The specific majors offered by the meta major + the assignment mechanism of major declaration in the meta major	The meta major of science includes the following specific majors: mechanical engineering, energy and power engineering, nuclear engineering and nuclear science, electronic information and electrical engineering, marine and marine engineering, materials science and engineering, biomedical engineering, chemical engineering, etc. The meta major involves both traditional "hot" and relatively "cold" majors and students enroll in the meta major without specific majors. Generally speaking, after one year of general education, students	The meta major of humanities includes the following specific majors: Chinese, foreign languages, history, philosophy, archaeology, etc. The meta major involves both traditional "hot" and relatively "cold" majors and students enroll in the meta major without specific majors. Generally speaking, after one year of general education, students select specific majors in the scope of the meta major based on individual preference, academic performance, college entrance examination scores and other relevant

	select specific majors in the scope of the class based on individual preference, academic performance, college entrance examination scores and other relevant provisions, however, there is no guarantee that everyone can enter a popular major.	provisions, however, there is no guarantee that everyone can enter a popular major.

Notes. The majors included in each meta major and the introductory descriptions are exactly copied from official texts in several selective colleges.

Experimental Analysis

We examine how students' preference for the meta major varies in respond to different information on characteristics of the meta major. The following linear probability model is used to estimate the effects of the three treatment conditions:

$$Y_{ij} = \beta_0 + \sum_{k=1}^{3} \beta_k \cdot T_{kij} + X_{ij} \cdot \gamma + \delta_j + \varepsilon_{ij} \quad (4\text{-}1)$$

where Y_{ij} is the outcome of interest for student i in school j. T_{kij} are the binary treatment indicators ($k = 1,2,3$), referring to the information interventions on the major list, benefit, and assignment mechanism, respectively; β_k indicate the average treatment effects of the interventions. X_{ij} is a vector of students characteristics, including gender, *Gaokao* scores, only-child status, hukou, parental educational attainment, major preference, [30] information sufficiency and sources[31], and the content of high school counseling.[32] δ_j are the high school fixed effects and ε_{ij} is the error term. All standard errors are clustered at the high school level.

We then examined the heterogeneous treatment effects using a linear interaction between the treatment indicator and individual characteristics. We were interested in the heterogeneous effects on students with different socioeconomic backgrounds, information resources, preferences, and risk attitudes. We hypothesized that students who are more constrained by behavioral barriers and lack of information and resources, respond more to the additional information in the experiment, based on the existing literature on informational nudging and qualitative evidence on meta-major.

[30] In the survey, students were asked to report whether they prefer to choose a major of interest, a popular major, jointly consider college and major, or prefer prestigious universities (multiple choice questions).
[31] In the survey, students were asked to report whether they have sufficient knowledge of universities and majors, and their main sources of information: self, counseling institute, teachers, parents, relatives, friends, etc. (multiple choice questions).
[32] In the survey, students were asked to report the main content of their career education, such as subject selection, college application, introduction to universities, etc. (multiple choice questions).

Results

Balance Test

The randomization was successful: The four groups were balanced in their observable student characteristics, given the student-level randomization. We conducted a one-way ANOVA across the different treatments for each observed variable and a multinomial logistic regression of the treatments on the observed variables. Table 4.2 shows that both the individual tests and the joint test indicate that there were no statistically significant differences in the students' covariates across the groups. The joint F test p-value from a multinomial logistic regression is 0.861, indicating that the observed students' characteristics do not predict the treatment assignments.

Table 4.2 Balance Checks

Variables	Control	T1	T2	T3	P-value
Female	0.598	0.580	0.577	0.579	0.139
	[0.490]	[0.494]	[0.494]	[0.494]	
STEM track	0.620	0.631	0.632	0.622	0.702
	[0.486]	[0.483]	[0.482]	[0.485]	
Gaokao score	491.121	494.815	493.538	492.567	0.840
	[179.372]	[176.483]	[177.585]	[179.331]	
Gaokao score missing	0.093	0.088	0.089	0.092	0.928
	[0.290]	[0.283]	[0.285]	[0.289]	
Only-child	0.397	0.404	0.409	0.402	0.664
	[0.489]	[0.491]	[0.492]	[0.490]	
Rural hukou	0.546	0.546	0.549	0.558	0.341
	[0.498]	[0.498]	[0.498]	[0.497]	
Parental college education	0.327	0.342	0.342	0.325	0.830
	[0.469]	[0.475]	[0.474]	[0.468]	
Sufficient information on college	0.560	0.569	0.575	0.574	0.232
	[0.496]	[0.495]	[0.494]	[0.495]	
Sufficient information on major	0.546	0.552	0.532	0.549	0.790
	[0.498]	[0.497]	[0.499]	[0.498]	
Prefer majors of interest	0.488	0.475	0.504	0.499	0.133
	[0.500]	[0.499]	[0.500]	[0.500]	

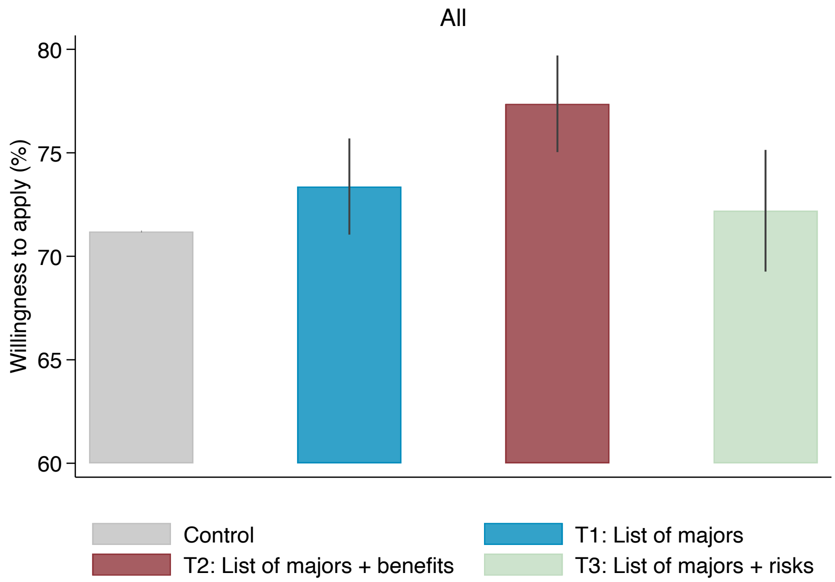
Prefer popular majors	0.163	0.166	0.163	0.179	0.151
	[0.370]	[0.372]	[0.370]	[0.384]	
Jointly consider college and major	0.531	0.532	0.506	0.517	0.101
	[0.499]	[0.499]	[0.500]	[0.500]	
Main information source: self	0.776	0.759	0.748	0.765	0.215
	[0.417]	[0.427]	[0.434]	[0.424]	
Main information source: counselling institute	0.102	0.102	0.113	0.112	0.109
	[0.302]	[0.302]	[0.317]	[0.315]	
Main information source: others	0.764	0.771	0.776	0.777	0.235
	[0.425]	[0.421]	[0.417]	[0.416]	
Career education: college application	0.288	0.298	0.295	0.292	0.835
	[0.453]	[0.457]	[0.456]	[0.455]	
Career education: college introduction	0.221	0.246	0.241	0.238	0.176
	[0.415]	[0.431]	[0.428]	[0.426]	
Observations	2,875	2,819	2,769	2,878	

Notes. The table reports the mean and standard deviation (in square brackets) of each variable. The joint F test p-value from a multinomial logistic regression is 0.861.

Average Treatment Effects

Figure 4.1 shows the mean of students' willingness to apply for the four groups. As expected, providing information on the potential benefits of meta-majors (T2) significantly increased students' willingness to apply, whereas providing information on the major list or the assignment mechanism and its associated risks had smaller, statistically insignificant impacts. Appendix B presents similar results separately for the high school academic tracks.

Figure 4.1 Mean Difference in Willingness to Apply across the Control and Treatment Groups



Notes. This figure shows the mean of students' willingness to apply across treatment and control groups with 95% confidence intervals. Students' willingness to apply is significantly higher for the treatment group T2.

Table 4.3 reports the linear probability model estimation results; columns (1–3) show the results for all students, and columns (4) and (5) report the results for the STEM-track and humanities-track students, respectively. Column (1) shows the regression results from the regression model (Equation 1), only containing the three treatment dummies. The result after controlling for the covariates is shown in Column (2), and Column (3)-(5) reports the result after including a full set of covariates and high school fixed effects. The first two rows report the control group's mean and standard deviation of the willingness to apply for a meta-major for reference, which are the same across different model settings.

Table 4.3 Treatment Effects of the Information Intervention on Students' Willingness to Apply

		All		STEM	Humanities
	(1)	(2)	(3)	(4)	(5)
Control	0.712	0.712	0.712	0.694	0.741
	[0.453]	[0.453]	[0.453]	[0.461]	[0.438]
T1	0.022*	0.016	0.016	-0.008	0.031
	(0.013)	(0.014)	(0.014)	(0.016)	(0.025)
T2	0.062***	0.060***	0.059***	0.044***	0.062***
	(0.013)	(0.014)	(0.014)	(0.017)	(0.021)
T3	0.015	0.010	0.010	-0.015	0.028
	(0.015)	(0.015)	(0.015)	(0.018)	(0.019)
T1=T2	{0.000}	{0.000}	{0.000}	{0.005}	{0.126}
T1=T3	{0.569}	{0.539}	{0.514}	{0.598}	{0.876}
T2=T3	{0.000}	{0.000}	{0.000}	{0.005}	{0.121}
Control Variables	N	Y	Y	Y	Y
High School FE	N	N	Y	Y	Y
Observations	11,424	11,424	11,424	7,101	4,323

Notes. The table reports the OLS regression results of the average treatment effects of meta major information on the willingness to apply. The standard deviation of outcome in the control group is reported in square brackets, robust standard errors are in parentheses, and the p-values of pairwise tests for equal coefficients between each pair of treatments are in curly brackets. Covariates are summarized in Table 4.2. ***, ** and * indicate statistical significance levels of 0.01, 0.05 and 0.10, respectively.

Without supplementary information, 71.2% of all students in the control group were willing to apply for meta-majors. The students in the humanities track had a higher interest (74.1%) than those in the science track (69.4%). We found that providing the benefit information (T2) of a meta-major significantly improved students' willingness to apply. After controlling for covariates and high school fixed effects, students who were presented with the benefit information were 6 percentage points more likely to apply for a meta major than those in the control group. Moreover, STEM-track students who were presented with the benefit information were 4.4 percentage points more likely to apply for a STEM meta major and humanities-track students were 6.1 percentage points more likely to apply for a humanity meta-major than their respective counterparts in the control group.

However, information about specific majors and assignment mechanisms has insignificant impacts. Information on specific majors (T1) and assignment mechanisms (T3) in major choice decreased the willingness to apply to a STEM meta major, both of which are statistically insignificant. The students in the humanities track were approximately three percentage points more likely to apply when receiving information on the major or assignment mechanisms. However, these differences were not statistically significant.

Heterogeneity in the Treatment Effects

The heterogeneous effects of information on students with different socioeconomic backgrounds, information resources, preferences, and risk attitudes are examined in this section. We estimated the heterogeneous treatment effects by using a linear interaction model and identified the main effect for the two groups separately within each category. We also identified the gap in the treatment effect between the two groups. Each category is an index that uses principal component analysis to summarize a set of items within the same domain. The results of heterogeneity in the treatment effects are summarized in Table 4.4. Appendix Table C. 4.1-4 present the itemized results for each category. These are qualitatively consistent with the main results.

Table 4.4 Heterogeneity in the Treatment Effects

	Background			Information			Preference			Risk attitude		
	Advantaged	Disadvantaged	Gap	Rich	Limited	Gap	Clear	Unclear	Gap	Risk-averse	Risk-taking	Gap
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Control	0.724	0.700		0.724	0.697		0.709	0.715		0.704	0.752	
	[0.447]	[0.459]		[0.447]	[0.460]		[0.454]	[0.452]		[0.457]	[0.433]	
T1	-0.006	0.041**	-0.047**	-0.016	0.047***	-0.064**	-0.008	0.040**	-0.048**	-0.003	0.106***	-0.109***
	(0.018)	(0.017)	(0.022)	(0.020)	(0.017)	(0.025)	(0.017)	(0.018)	(0.022)	(0.017)	(0.032)	(0.038)
T2	0.050***	0.071***	-0.021	0.027	0.091***	-0.064**	0.044**	0.075***	-0.031	0.033*	0.182***	-0.149***
	(0.016)	(0.020)	(0.025)	(0.018)	(0.019)	(0.026)	(0.018)	(0.016)	(0.022)	(0.017)	(0.032)	(0.039)
T3	0.007	0.016	-0.009	-0.032*	0.052***	-0.084***	-0.022	0.043*	-0.065**	-0.008	0.097***	-0.105***
	(0.019)	(0.020)	(0.025)	(0.019)	(0.019)	(0.024)	(0.017)	(0.022)	(0.026)	(0.018)	(0.034)	(0.040)
Observations	5,736	5,688		6,307	5,117		5,571	5,853		9,358	2,066	

Notes. The gap in treatment effects across different groups is measured using the coefficients of interactions between the treatment and group indicators. All the regressions include covariates and province fixed effects. Robust standard errors are in parentheses. ***, ** and * indicate statistical significance levels of 0.01, 0.05 and 0.10, respectively.

Columns 1–3 show that students from disadvantaged backgrounds were more likely to respond to additional information and to change their application behaviors. We evaluated students' socioeconomic status by using the predicted standardized factor scores of students' residence, their hukou, parental education, and high school type. These variables correlated with students' *objective* access to college choice information. As shown in Appendix Table C. 4.1, students with rural hukou, first-generation students, or students who graduated from non-selective high schools responded more to the additional information.

Additional information has the most substantial effect on students who *subjectively* reported having limited access to accurate college-major choice information (Columns 4–6). We used self-reported information sources and quantities to assess students' information access. Specifically, when high schools do not provide the necessary guidance, and students cannot get access to sufficient information on colleges and majors, they are more likely to be affected by the additional information. Moreover, students who take the initiative to collect information are less likely to trust and process additional information.

When combined, insufficient information and a lack of guidance may be the primary mechanisms through which students' backgrounds affect their behaviors and inequality in college major choice. The information divide and the consequent differences in their major choice and performance between advantaged and disadvantaged students were also frequently mentioned in online discussions, as per our text data. For example, students constantly debated over which group of students may benefit from the reform, and whether delaying their major choice intensifies the inequality in college major choice and long-term outcomes.

Columns 7–9 show that students with clear college major preferences are less affected by the information provided in the experiment. This highlighted the importance of providing information and guidance early on to help students form their college major choice preferences. However, even with those students who reported clear college major preferences, receiving information about the benefits of meta-majors still largely changed their preferences.

Since meta-majors impose large uncertainties in the final major declaration and college success outcomes, students who are more risk-loving were more responsive to new information, especially regarding the information on assignment mechanisms. Risk-loving students would take the opportunity of choosing meta majors to compete for popular majors. This occurs when their college entrance exam scores are inadequate to choose those majors in colleges with the college-and-major application policy.

Male students responded to all types of information, while female students only responded to the benefit information (Appendix Table C. 4.4 Columns 1–3). The average null effect of major and risk information on their application is masked by the significant gender gap in the treatment effects, specifically, female students responded more negatively, while males responded more positively. Consistent with the present empirical evidence, the positive effect of the risk information for male students suggests that they tend to be more competitive, more overconfident, less risk-averse, and less patient than women (Zafar, 2013; Buser et al., 2014; Reuben et al., 2017; Patnaik et al., 2020). All of these different traits are related to student attitudes to meta major after receiving the information. Students with different willingness to compete, confidence levels, risk attitudes, levels of patience, and persistence may react differently. I use three-way interactions to explore the moderation effects of the above traits in explaining the gender differences in responses to information. First, meta major is a relatively more competitive option since students have to compete for their preferred majors after one- or two years' study. Second, the level of confidence determines student beliefs about their absolute and relative performance and their estimated probability of getting access to a preferred major and success in a meta major. Third, in terms of the assignment mechanisms of meta major, students are faced with the risk of ending up with a less-preferred major. Finally, the first one or two years of study before selecting the final major requires students to consistently contribute efforts.

Discussion

The experiment presented above yields some interesting findings of the role of various information on student major application intent. In this section, we will discuss these results from the following perspectives: meta major settings, benefits, and assignment mechanisms.

Meta Major Setting: a Package of "Hot" and "Cold" Majors

The insignificant effect of T1 (the information of specific majors) indicated that students were almost neutral to the information of specific majors, as both popular and less popular majors were included in the list. In order to examine students' preferences for the meta-major reforms, such as their perceptions and experiences with different major settings, we analyzed text data obtained from a popular Chinese online discussion board (zhihu.com). Zhihu.com is similar to quora.com, and the data have been used by researchers to analyze other higher education policies (Eble & Hu, 2021). We collected open-ended questions and responses related to the meta-major reforms (as of August 31, 2021). We then coded the data into the domains or topic areas to characterize the common patterns.[33] The text data richly characterize how students

[33] We used a two-stage procedure to code the text data: We first generated an initial codebook and grouped the major themes based on the initial transcripts and codes. Next, we refined the coding system during the process of conducting focus group interviews. In the second stage, we compared the coded results from zhihu.com and the interviews and identified additional themes. Furthermore, we used the

perceive meta-majors and how they could influence their college choice. A discussion on the meta-majors took place on the board from diverse perspectives, including individual students, institutions, and society at large. We identified qualitative themes relevant to the meta-major reforms and conducted supplemental case studies, which included focus group interviews with 22 high school graduates during the college application seasons in 2020 and 2021 and 6 college students in meta-majors. The full themes and summaries are presented in Appendix Table D. 4.1.

Some respondents (college students) critique the unreasonable major and the course setting in meta-majors. Many colleges tend to combine popular and unpopular majors into a meta-major to increase their admissions competencies. One respondent commented on the negative aspect of this institutional behavior: *In order to 'sell' unpopular majors, universities bundle popular and unpopular majors together, such as placing computer and biomedicine under the same category or combining civil engineering, materials, automation, and electronics into a meta major named new computer intelligence engineering.*

Relevantly, the field of study may be too broad for students to focus their time and energy on the fields that they have interests and passion in, and students in meta-majors seem to have unsatisfying experiences: *Students are forced to experience different majors; however, they cannot learn anything in-depth but just try to earn enough credits to fulfill the requirement. Most students do not want to waste a year on things that are not relevant to their final major.* Additionally, many students talked about the heavy study burden in meta-major as they have too many courses to learn: *Students enrolling in a meta major have to take more than 20 courses each year, stay up late, and never finish their homework.*

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frequencies of the responses or commonly highlighted themes for the main analysis, as presented in the main text.

Overall, although meta-major includes some popular majors that students want to pursue, it also contains some less popular majors and thus distracts students' study focus and exerts extra study burden on students, and also puts tudents under the risk of entering a less preferred or unpopular major. Therefore, the information on specific majors has no significant effect on students' application intent.

Benefit: the Most Powerful Information

Recall the experimental results, the most salient effect came from the benefits information (T2). However, students had limited access to and knowledge of these benefits. Typically, college information sessions, recruitment materials, or social media provide such information. However, not all students could access this information, even though it was freely accessible. Some students may intentionally or unintentionally ignore or forget such information due to a lack of attention (Damgaard & Nielsen, 2020). In line with our field observations and policy reviews, information friction affects students' (especially disadvantaged students) understanding of the benefits and costs of choosing a meta-major. Consequently, students' decision-making was not influenced by the reform, as supposed, due to a lack of accurate information.

Assignment Mechanisms: the Coexistence of Opportunity and Risk

The *ex-ante* effect of the information on the assignment mechanisms (T3) was mixed. Postponing the final major choice by one or two years after their enrollment was beneficial for students who needed more time to learn and discover their interests and advantages before making a choice. One of the respondents from Zhihu.com noted that *The meta major reform* *helps students to choose their majors rationally after learning more about the characteristics of each major.* However, the delay of the major decision may signal the risk of entering less-favored majors. The assignment mechanisms also place students under great pressure as the assignment into a specific major largely depends on their academic performance in college, for example, one mentioned that: *As competition intensifies, they are under great pressure and have to constantly improve their competitiveness.*

In real settings, the assignment mechanisms are usually unclear, and vary substantially across universities. Most students have no clear knowledge of the major assignment rules until they enter college or before their final major choice. Understanding the complicated assignment mechanism and predicting their probabilities of being assigned to different specific majors may be a major challenge for students, as one noted the following: *Students have biased beliefs about their own ability and the probability of admitting into their intended majors.* Additionally, the insignificant effects of the assignment mechanism information may be partly explained by the fact that students may be overconfident about their probability of obtaining high grades and entering a popular major (Damgaard & Nielsen, 2020). On the online discussion board, people jokingly commented on the "Pareto principle of meta major," that *80% of the students believe that they will be in the top 20% of the class*"; thus, most of them do not worry about the potential risks in the assignment of their final major.

Students with different perceptions of the assignment mechanism may respond differently to the corresponding information intervention (T3). Consequently, the information produced overall insignificant effects.

Conclusion

This paper provides one of the first experimental evidence on the heterogeneous impacts of college-major to college-then-major reforms on students' college-major choice preferences. With a nationally representative sample of 11,424 high school graduates, we conducted a randomized informational intervention on the students' college-major choices by providing individuals with detailed information about meta-majors. The experimental results showed that providing information on the benefits statistically significantly improved students' willingness to apply to the meta-majors by about six percentage points (versus the control mean of 71.2%); however, information about the specific majors and assignment mechanisms had insignificant effects on their willingness to apply. All three types of information affected the preferences of students who had limited access to college-major choice information and guidance, which also applied to those who did not have strong preferences for specific majors, or who were risk-loving. Finally, building on the qualitative evidence, we explained the results in terms of meta major settings, benefits and assignment mechanisms.

Meta majors provide students with both general and major-specific knowledge and varied career opportunities. In college applications, meta-majors simplify students' choices by reducing the number of initial options and delaying the final specialization. This allows students to explore and develop their major-specific interests at a low switching cost. However, under the meta-major policy, students face the challenges of incomplete or imperfect information about the major and curriculum settings, streaming mechanisms, and so on. Specifically, the reform combines popular and unpopular majors. Therefore, students are faced with great risk and uncertainty in their ultimate major choice, for instance, students with low grades may be prevented from declaring some popular majors. Students must consider all these complicated characteristics of a meta-major, considering both the benefits and risks when choosing a college major. We provide consistent results for the experimental findings and qualitative evidence.

Our paper has important implications for the design of meta majors, which are increasingly commonly used by many countries that are either moving away from college-major admissions or college-and-major admissions. According to the experimental results, the benefit information on the multi-disciplinary training of a meta-major exerts the most significant impact on students' intent to apply. Students attach great importance to the training mode and course setting, and value the cross-disciplinary and innovative components of meta-majors. The curriculum and training mode of meta-majors should remain the top priority in the expansion and deepening of the meta-major reform. Instead of simply combining popular and unpopular majors and increasing students' workload, universities should pay more attention to the knowledge, skill, and career development of students in the meta majors. More efforts should be made in the curriculum setting, teaching quality, supporting resources, and career planning. In addition, universities should also provide more complete and clear information on the benefits and the assignment rules for each major option, which is currently unavailable to most students.

Furthermore, the information has the greatest effect on the individuals most affected by the information barrier, such as students from disadvantaged backgrounds. The results inform future work on designing targeted information interventions to offer incentives and/or overcome information barriers in college major choices for disadvantaged students. For example, students from rural areas lack reliable information sources and sufficient information on their college major choices. Advising, guidance, and assistance in college applications provided by high schools or other institutions are essential for them to learn the advantages and disadvantages of the different options. They could then shortlist their potential choices and make the optimal decision.

Future studies could investigate the long-term effects of the meta-major reforms by tracking students to study their final major choice, college engagement, college completion, and education or employment after graduation. Additionally, studies that make further progress on studying the assignment mechanisms of meta-majors to overcome the uncertainties and barriers students face in their final major choice will also be important for the designs of college-major choice mechanisms for improving student-major match and college success.

Appendix A: Information Students Can Obtain from the Application Guidebook

Figure A. 4.1 Admission Instructions of Tsinghua University

A. Major List, Quota, and Admission Scores

1104	清华大学	理科试验班类(经济、金融与管理)	2	705	709
		理科试验班类(新雅书院)	1	701	701
		工科试验班类(机械、航空与动力)	1	695	695
		工科试验班类(自动化与工业工程)	2	694	694
		建筑类	1	700	700
		电子信息类	3	696	698
		土木类	1	695	695
		计算机类	8	698	714
		工科试验班类(能源与电气)	3	695	697
		理科试验班类(数理)	1	697	697

Translation:

1104	Tsinghua University	Science meta major (Economics, Finance, and Management)	2	705	709
		Science meta major (Xinya College)	1	701	701
		Engineering meta major (Mechanical Engineering, Aeronautical Engineering, Power Engineering)	1	695	695
		Engineering meta major (Automation and Industrial Engineering)	2	694	694
		Architecture meta major	1	700	700
		Electronic Information meta major	3	696	698
		Civil engineering meta major	1	695	695
		Computer science meta major	8	698	714
		Engineering meta major (Energy and Electric Engineering)	3	695	697
		Science meta major (Math and Physics)	1	697	697

B. Major List, Quota, Tuition, and Specific Majors

1104 清华大学

计划招生:21名

办学地点:清华大学

[00] 工科试验班类(机械、航空与动力) 4年 5000元/年 3名

【包含专业：机械工程、机械工程(实验班)、测控技术与仪器、能源与动力工程、车辆工程、车辆工程(电子信息方向)、车辆工程(车身方向)、工业工程、航空航天类、工程力学(钱学森力学班)】

[02] 计算机类 4年 5000元/年 1名

【包含专业：计算机科学与技术、软件工程、计算机科学与技术(计算机科学实验班)、计算机科学与技术(智班)】

[03] 工科试验班类(环境、化工与新材料) 4年 5000元/年 1名

【包含专业：环境工程、环境工程(全球环境国际班)、化学工程与工业生物工程、高分子材料与工程、材料科学与工程】

[04] 自动化类 4年 5000元/年 1名

【包含专业：自动化、信息管理与信息系统】

[05] 理科试验班类(数理) 4年 5000元/年 1名

【包含专业：数学与应用数学、物理学、数理基础科学、工程物理、工程物理(能源实验班)】

Translation:

1104 Tsinghua University
Admission quota: 21
Location: Tsinghua University

[00] Engineering meta major (Mechanical Engineering, Aeronautical Engineering, Power Engineering)
4 years, 5000 yuan/year ($782), quota: 3
Including Mechanical Engineering, Mechanical Engineering (experimental class), Measurement and Control Technology and Instruments, Energy and Power Engineering, Vehicle Engineering, Vehicle Engineering (Electronic Information), Vehicle Engineering (Vehicle Body), Industrial Engineering, Aerospace Engineering, Mechanics (Xuesen Qian Mechanics Class)

[02] Computer science meta major
4 years, 5000 yuan/year ($782), quota: 1
Including Computer Science and Technology, Software Engineering, Computer Science and Technology (Computer Science Experimental Class), Computer Science and Technology (Zhi Class)

[03]-[05] omitted

Note. The two screenshots are from the official college application guidebook in 2020 in Chongqing.

Each province uses the nearly identical format and information.

Figure A. 4.2 Admissions Prospectus of Shanghai Jiaotong University (Assignment Mechanism)

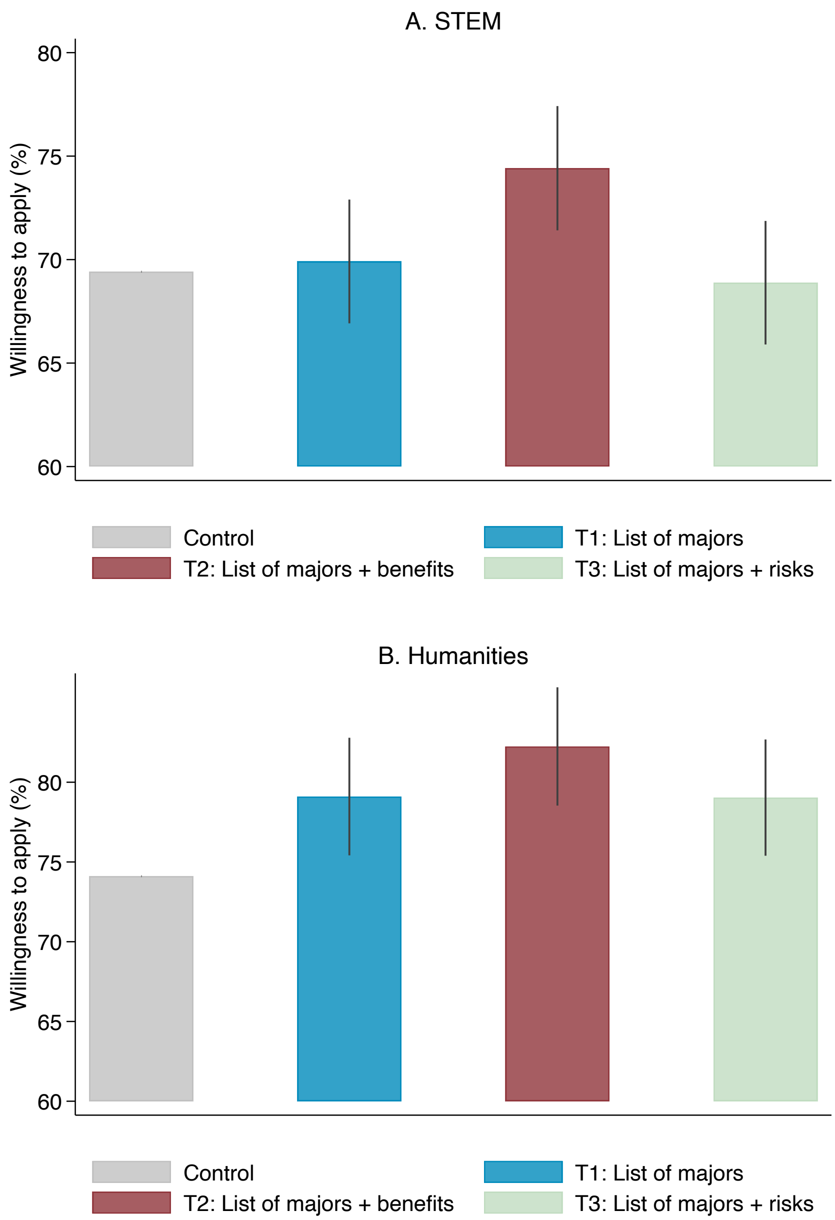
第十四条 上海交通大学实行按平台、院（类）招生的学生入学时不分具体专业。一般在入学后，根据考生志愿、高考成绩及学校相关测试与规定，在所在平台、院（类）范围内进行专业分流。

Translation:
Article 14: Shanghai Jiaotong University recruits students based on platforms and colleges (meta majors) without assigning into specific majors. Generally, major assignment will be carried out within the platform and college (meta majors) based on student preference, college entrance examination scores, tests scores in college, and other regulations.

Note. This screenshot shows the information relevant to meta major assignment mechanism from a university's official Admissions Prospectus. Source: https://Gaokao.chsi.com.cn/zsgs/zhangcheng/listVerifedZszc--infoId-3136310872,method-view,schId-199.dhtml

Appendix B: Treatment Effects

Figure B. 4.1 Treatment effects by academic track in the College Entrance Exam



Appendix C: Heterogeneity in the Treatment Effects

Table C. 4.1 Heterogeneity in the Treatment Effects: Access To Information

	Access to Information											
	Urban hukou	Rural hukou	Gap	Second-generation	First-generation	Gap	Selective high school	Non-selective high school	Gap	Advantage background	Disadvantage background	Gap
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Control	0.725	0.701		0.728	0.704		0.726	0.696		0.724	0.700	
	[0.447]	[0.458]		[0.445]	[0.457]		[0.446]	[0.460]		[0.447]	[0.459]	
T1	-0.010	0.040**	-0.050**	-0.002	0.027*	-0.028	0.002	0.035**	-0.033	-0.006	0.041**	-0.047**
	(0.019)	(0.016)	(0.024)	(0.020)	(0.016)	(0.024)	(0.022)	(0.016)	(0.027)	(0.018)	(0.017)	(0.022)
T2	0.047***	0.072***	-0.025	0.043**	0.070***	-0.027	0.053***	0.070***	-0.017	0.050***	0.071***	-0.021
	(0.017)	(0.019)	(0.024)	(0.019)	(0.018)	(0.027)	(0.019)	(0.018)	(0.025)	(0.016)	(0.020)	(0.025)
T3	-0.001	0.022	-0.023	0.002	0.016	-0.015	0.002	0.022	-0.020	0.007	0.016	-0.009
	(0.021)	(0.018)	(0.026)	(0.022)	(0.017)	(0.026)	(0.020)	(0.019)	(0.026)	(0.019)	(0.020)	(0.025)
Observations	5,151	6,273		3,825	7,599		6,076	5,348		5,736	5,688	

Notes. The gap in treatment effects across different groups is measured using the coefficients of interactions between the treatment and group indicators. Robust standard errors are in parentheses. ***, ** and * indicate statistical significance levels of 0.01, 0.05 and 0.10, respectively.

Table C. 4.2 Heterogeneity in the Treatment Effects: Sources And Quantity Of Information

	Information sources						Quantity of information					
	Self	Other	Gap	Counseling institute	Other	Gap	Sufficient knowledge of college	Insufficient	Gap	Sufficient knowledge of major	Insufficient	Gap
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Control	0.714	0.705		0.661	0.718		0.722	0.699		0.720	0.702	
	[0.452]	[0.456]		[0.474]	[0.450]		[0.448]	[0.459]		[0.449]	[0.457]	
T1	-0.009	0.116***	-0.125***	0.017	0.017	0.000***	-0.022	0.067***	-0.089***	-0.013	0.053***	-0.067**
	(0.015)	(0.026)	(0.028)	(0.014)	(0.014)	(0.000)	(0.017)	(0.016)	(0.020)	(0.021)	(0.016)	(0.027)
T2	0.042***	0.128***	-0.086***	0.060***	0.060***	0.000***	0.028*	0.101***	-0.074***	0.037*	0.088***	-0.052*
	(0.016)	(0.024)	(0.030)	(0.013)	(0.013)	(0.000)	(0.015)	(0.019)	(0.022)	(0.020)	(0.018)	(0.027)
T3	-0.014	0.106***	-0.120***	0.011	0.011	0.000***	-0.026	0.059***	-0.085***	-0.021	0.050***	-0.072***
	(0.016)	(0.034)	(0.038)	(0.015)	(0.015)	(0.000)	(0.016)	(0.020)	(0.022)	(0.019)	(0.019)	(0.024)
Observations	8,644	2,780		1,214	10,210		6,460	4,964		6,181	5,243	

Notes. The gap in treatment effects across different groups is measured using the coefficients of interactions between the treatment and group indicators. Robust standard errors are in parentheses. ***, ** and * indicate statistical significance levels of 0.01, 0.05 and 0.10, respectively.

Table C. 4.3 Heterogeneity in the Treatment Effects: Major Choice Preference

	Preference											
	Prefer majors of interest	Other	Gap	Prefer popular majors	Other	Gap	Prefer prestigious universities	Other	Gap	Jointly consider college and major	Other	Gap
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Control	0.709	0.715		0.698	0.715		0.757	0.687		0.693	0.733	
	[0.454]	[0.452]		[0.460]	[0.452]		[0.429]	[0.464]		[0.461]	[0.442]	
T1	-0.008	0.040**	-0.048**	0.020	0.016	0.004	-0.035	0.044**	-0.079**	0.014	0.021	-0.007
	(0.017)	(0.018)	(0.022)	(0.028)	(0.014)	(0.027)	(0.022)	(0.020)	(0.032)	(0.023)	(0.021)	(0.034)
T2	0.044**	0.075***	-0.031	0.028	0.067***	-0.039	0.027	0.076***	-0.049**	0.056***	0.065***	-0.009
	(0.018)	(0.016)	(0.022)	(0.031)	(0.014)	(0.033)	(0.019)	(0.017)	(0.024)	(0.021)	(0.018)	(0.028)
T3	-0.022	0.043*	-0.065**	0.024	0.009	0.016	-0.030	0.032*	-0.062**	0.007	0.016	-0.009
	(0.017)	(0.022)	(0.026)	(0.036)	(0.014)	(0.034)	(0.023)	(0.017)	(0.028)	(0.021)	(0.021)	(0.029)
Observations	5,571	5,853		1,905	9,519		4,135	7,289		5,915	5,509	

Notes. The gap in treatment effects across different groups is measured using the coefficients of interactions between the treatment and group indicators. Robust standard errors are in parentheses. ***, ** and * indicate statistical significance levels of 0.01, 0.05 and 0.10, respectively.

Table C. 4.4 Heterogeneity in the Treatment Effects: Gender, Risk Attitudes, Career Education

	Gender			Risk attitude			Career education		
	Female	Male	Gap	Risk-averse	Risk-taking	Gap	College introduction and application	Other contents	Gap
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Control	0.690	0.745		0.704	0.752		0.762	0.688	
	[0.463]	[0.436]		[0.457]	[0.433]		[0.426]	[0.464]	
T1	-0.009	0.053***	-0.062**	-0.003	0.106***	-0.109***	-0.005	0.029**	-0.034
	(0.018)	(0.019)	(0.026)	(0.017)	(0.032)	(0.038)	(0.027)	(0.013)	(0.027)
T2	0.048**	0.078***	-0.030	0.033*	0.182***	-0.149***	0.034	0.074***	-0.040
	(0.019)	(0.014)	(0.022)	(0.017)	(0.032)	(0.039)	(0.032)	(0.014)	(0.037)
T3	-0.009	0.040**	-0.049*	-0.008	0.097***	-0.105***	0.001	0.017	-0.016
	(0.020)	(0.018)	(0.025)	(0.018)	(0.034)	(0.040)	(0.024)	(0.015)	(0.024)
Observations	6,650	4,774		9,358	2,066		3,826	7,598	

Notes. The gap in treatment effects across different groups is measured using the coefficients of interactions between the treatment and group indicators. Robust standard errors are in parentheses. ***, ** and * indicate statistical significance levels of 0.01, 0.05 and 0.10, respectively.

Appendix D: Qualitative Analysis Results

Table D. 4.1 Student Perceptions of the Meta Major Reform

Theme	Summary
Imperfect information	Only by correctly understanding the setting and essence of meta major, not being blinded by the fine words of any school, can candidates maximize their benefits in college application.
Major setting	In order to 'sell' unpopular majors, universities bundle popular and unpopular majors together, such as placing computer and biomedicine under the same category, or combining civil engineering, materials, automation, and electronics into a meta major named new computer intelligence engineering.
General field of study	Students are forced to experience different majors; however, they cannot learn anything in-depth but just try to earn enough credits to fulfill the requirement. Most students do not want to waste a year on things that are not relevant to their final major.
Benefits	The meta major reform helps students to choose their majors rationally after learning more about the characteristics of each major. It is good for students to have more choices, especially for those with high grades.
Assignment mechanisms	For college applicants, the meta major policy benefits low-scoring candidates while high-scoring candidates suffer. It weakens the role of the college entrance examination and provides opportunities for low-scoring candidates to 'counterattack' and choose popular majors. Students have biased beliefs about their own ability and the probability of admitting into their intended majors.
Study burden, competition and Involution	Students enrolling in a meta major have to take more than 20 courses each year, stay up late, and never finish their homework. As competition intensifies, they are under great pressure and have to constantly improve their competitiveness.
Recruitment strategy	Universities benefit from the meta major reform by combining popular major with unpopular majors, which may attract more students to apply, and increase the admission scores and the quality of candidates.
Education equity	The meta major reform may bring more unfairness in education. Before the reform, students from provinces with poor educational resources may still had chances to enter some good majors if enough college-major quota was assigned and they met the minimum entry score. But, after the reform, it will become extremely hard for them to succeed in the competition against other advantaged students under the unique admission requirement. Students compete at the same starting line and under the same standard, and only students with good grades could get access to good majors, which can effectively alleviate the unfairness and injustice caused by different admission policies across provinces.

Note. Sources: www.zhihu.com, focus interviews with 22 high school graduates during the college application seasons in 2020 and 2021 and 6 college students in meta-majors.

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