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College-major choice to college-then-major choice: Experimental evidence from Chinese college admissions reforms

Liping Ma [a], Xin Li [b,*], Qiong Zhu [a], Xiaoyang Ye [c]

[a] Institite of Economics of Education, Graduate School of Education, Peking University, Beijing, China
[b] Center for Applied Social and Economic Research, NYU Shanghai, China
[c] Annenberg Institute for School Reform, Brown University, Providence, Rhode Island, United States

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ABSTRACT

One of the most important mechanism design policies in college admissions is to let students choose a college major sequentially (*college-then-major* choice) or jointly (*college-major* choice). In the context of the Chinese meta-major reforms that transition from *college-major* choice to *college-then-major* choice, we provide the first experimental evidence on the information frictions and heterogeneous preferences that students have in their response to the meta-major option. In a randomized experiment with a nationwide sample of 11,424 high school graduates, we find that providing information on the benefits of a meta-major significantly increased students' willingness to choose the meta-major; however, information about specific majors and assignment mechanisms did not affect students major choice preferences. We also find that information provision mostly affected the preferences of students who were from disadvantaged backgrounds, lacked accurate information, did not have clear major preferences, or were risk loving.

1. 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, Wiswall, & Zafar, 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 countries such as the United States and Canada, which allow students to declare a major after they enroll at colleges, many other countries employ *college-major* admissions policies that require students to choose a college-major pair jointly when they submit their applications (Bordon & Fu, 2015; Che, Hahm, Kim, Kim, & Tercieux, 2022; Kirkeboen et al., 2016; Krussig & Neilson, 2021; Machado & Szerman, 2021; Meyer, Leuze, & Strauss, 2021).[1] The *college-major* choice provides students with more specialized training upon college enrollment and helps confer degrees quickly and efficiently. Alternatively, the *college-then-major* choice allows students to explore and develop their major-specific interests during college with a low switching cost. The question as to which policy is better for a targeted group of students depends on students' sorting behaviors, which may be relevant to students' academic achievement, major choice preferences, risk attitudes, and information frictions they encounter in the application process; however, little is known about how students would behaviorally respond to the two different college major choice policies.

This paper fills this gap by examining students' college-major choice behaviors in a recent national reforms of college-major admissions in China, which has the world's largest centralized college matching market (Chen & Kesten, 2017). The reforms, allowing a subset of elite colleges to switch from the traditional *college-major* applications and admissions to *college-then-major* applications and admissions, have been implemented in China in the past two decades. The core of the

* Corresponding author: Center for Applied Social and Economic Research, NYU Shanghai, China.
E-mail address: xl4749@nyu.edu (X. Li).

[1] 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/). Che, Hahm, Kim, Kim, & Tercieux, 2022 note that colleges in major countries such as Chile, China, England, France, Germany, Japan, South Korea, Spain, and Turkey employ the college-major choice; or as they call it, immediate-major choice (vs. deferred-major choice).

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university-level reforms is the implementation of meta-major, which clusters relevant academic majors into a larger cohesive bucket (e.g., a science meta-major includes all science-related majors).[2] These meta-major reforms across colleges 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 to helping students discover their comparative advantage and increases student-major match quality and student welfare (Bordon & Fu, 2015; Che, Hahm, Kim, Kim, & Tercieux, 2022). A meta-major simplifies major choices when applying to colleges, delays students' final major declaration, and provides a wide range of deferred major choice opportunities that improve students' major fits. However, unless all students can freely declare the majors in which they are most interested, they face significant uncertainties in the final major choices and risks of being assigned to less-preferred majors during college. Thus, the effects of meta-major reforms on students' college-major choice behaviors are ambiguous, depending on how students respond to different components and characteristics of the reforms. In a companion paper (Li, Ma, Ye, & Zhu, 2022), using unique administrative data on college-major admissions over 18 years, we identify the policy impacts of the staggered adoption of the reforms across institutions on student composition using a difference-in-differences design. We find that the meta-major reforms generally have a minimal impact on the distribution of ability and demographic characteristics of students by college-majors, suggesting that the meta-major reforms do not significantly change students' college-major choice behaviors.[3]

In this paper, using a randomized experiment with a nationwide sample of college applicants, we focus on understanding why students did not respond to the *college-then-major* reforms in a favorable way as expected by policymakers and institutional practitioners. One important reason might be information frictions. That is, students lack critical information on meta-majors when they compare a meta-major option consisting of many majors in a cluster with other traditionally single college-major options. As we will discuss in detail later, the official guide that the Ministry of Education provides to college applicants often does not list the specific majors contained in a meta-major, nor information about how students would be eventually assigned to specific majors after enrolling in a meta-major. Additionally, students may also have incomplete information or biased beliefs about the potential benefits and risks associated with *college-then-major* choice versus *college-major* choice (Patnaik, Wiswall, & Zafar, 2020). Therefore, students' college-major choices can be largely affected by what information about a meta-major is available to them and how the information is presented, communicated, or consumed.

This paper presents the first experimental evidence on the information frictions and heterogeneous preferences that students have in their response to the meta-major option. Using a large-scale randomized informational experiment with a random sample of nationwide college applicants, we examine the impacts of different information components about meta-majors on students' college-major choices. We further study to what extent students' heterogeneous preferences mediate how they respond to various kinds of information on meta-majors. By combining the experimental evidence with text data obtained from a popular Chinese online discussion board, our results provide novel implications on the heterogeneous impacts and potential mechanisms of the *college-major* to *college-then-major* reforms on students' college-major choice decisions.

We collaborated with the Chinese Society of Educational Development Strategy (CSEDS), the primary think tank of the Ministry of Education of China, to implement the experiment with a nationwide sample of high school graduates of class 2020 (11,424 students from 268 high schools) via an online survey platform. The survey was conducted by the CSEDS to monitor high school students' development and the consequences of college admissions by randomly sampling nationwide. We took advantage of the survey to test the impacts of the three most important information elements of the meta-major reforms summarized from the explorative qualitative analysis prior to the experiment: (1) the specific majors offered by a meta-major, (2) the benefits of choosing a meta-major versus choosing a specific major, and (3) the assignment mechanisms and corresponding risks of major declarations in a meta-major. When making their college major choices, students may be provided with information on the specific majors offered by each meta-major; however, this information may not be salient enough for many students.[4] Moreover, students may have information frictions in accessing and/or understanding the information about the benefits and the assignment mechanisms (Arcidiacono et al., 2016). In our experimental module, students were asked to declare their willingness to choose a meta-major (versus the traditional college majors) after being randomly presented with different pieces of information related to the meta-major.

Results show that information regarding the benefits of meta-majors statistically significantly increased students' willingness to apply to them by approximately 6 percentage points. This was an 8 percent increase from the control mean of 71%. In contrast, information about specific majors and assignment mechanisms did not significantly affect students' willingness to apply to a meta major. We find clear evidence that students held heterogeneous beliefs on multiple aspects of a meta-major, which could affect their major choice: all three types of information had larger impacts 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) risk lovers.

To interpret those 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 analysis shows that students varied greatly in their responses to the meta-major reforms based on their heterogeneous beliefs. Some students were concerned about various aspects of the meta majors, including, but not limited to, major and course settings, cross-disciplinary training, study burden, assignment mechanisms, and education equity. Some students had different opinions and attitudes toward this new meta-major setting, which may be correlated with their information frictions driven by their socioeconomic background. Those

[2] Universities combine similar disciplines and majors within or across departments and recruit students according to the meta major category. When students make their college application, they can select the meta majors instead specific majors, which is the case under the traditional jointly college-major application and admission. Meta-major settings are different across institutions and generally follow three different admission modes: (1) admission by first-level or second-level disciplines; (2) admission by departments or schools; (3) admission by "base classes" or "experiment classes". After being admitted to a meta major, students study the general courses during the first or the first two academic years and re-select specific majors from the meta major bucket after that. The re-selection procedure differs greatly across institutions and majors, which is a two-way choice determined both by the schools' admission requirements and policy and students' interests and expertise.

[3] Similarly, a working paper by Kang et al. (2022) examines early reforms in 2006-2011 and finds that the admission scores for meta majors are higher than those for single-subject majors by only 0.03 standard deviations or 1.8 points in raw scores out of 750 points, which is close to our estimates in Li, Ma, Ye, & Zhu, 2022 as a relatively small policy impact.

[4] Students may only pay attention to the names of meta-majors and the popular majors within them, which are more salient and hence likely to impact their choices. However, some universities make the meta-majors like "blind boxes", which bundle irrelevant majors together and make the final major result a mystery for students. For example, the computer science meta major of a university also contains all engineering majors, such as civil engineering, hydraulic engineering, marine engineering, material engineering, etc.

results are consistent with the experimental findings. Given that information frictions are common among Chinese college applicants (Ye, 2023), the increased willingness of applying to meta majors from simple information provision also helps explain the null impacts of the reforms on students' actual college application behaviors as documented in Li, Ma, Ye, & Zhu, 2022.

Our paper contributes new empirical evidence in the following three aspects. First, since most countries only use one type of admission mechanisms (*college-major* choice or *college-then-major* choice), little is known about the potential consequences of switching from one mechanism to the other.[5] The meta-major reforms from *college-major* choice to *college-then-major* choice in China provide us with a unique opportunity to study students' preference between *college-major* choice and *college-then-major* choice. We extend the literature by integrating a randomized experiment on 11,424 high school graduates with qualitative analysis and providing one of the first pieces of empirical evidence on different major-choice mechanisms. Second, students across the world are all confronted with the problems of information frictions in choosing a college major.[6] The meta-major reforms, as important university-level reforms that switch from *college-major* to *college-then-major* admissions, greatly affect students' college choices and subsequent careers. However, students face more challenges in obtaining and analyzing information about what the meta-major means and how their final majors would be determined in a meta-major. We use the experiment to test how varied information would affect students' decision-making. The results provide the evidence base for future policy-making to improve the major choice mechanism designs. Finally, in the early years of the meta-major reforms, colleges also faced certain uncertainties about how to cluster different majors into one meta-major. They also lack knowledge about how students with heterogeneous preferences respond to different meta-majors and related information exposure. Our paper provides pivotal implications not only for students making one of the most important decisions of their lives but also for higher education institutions reforming college-major choice mechanisms to attract a more talented and diverse student body.

2. Related literature

The comparative desirability of *college-major* choice and *college-then-major* choice depends on students' college-major preferences and their dynamic decision-making (Bordon & Fu, 2015; Che, Hahm, Kim, Kim, & Tercieux, 2022). The classic decision-making theory asserts that people are aware of all the available choices and can 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). In this case, a fully rational and informative college applicant prefers or benefits from choosing a specific college-major before or early in college.

However, a more realistic educational selection process should incorporate uncertainty about future graduation and post-graduation outcomes, as well as the learning about one's own abilities and the characteristics of certain options (Arcidiacono et al., 2016; Gong, Stinebrickner, & Stinebrickner, 2022; Patnaik, Wiswall, & Zafar, 2020; Stinebrickner & Stinebrickner, 2012). Uncertainty and option value are the central features of educational investment (Stange, 2012). In the context of college major choices, 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, and/or labor market returns to certain fields (Ding et al., 2021; Fricke et al., 2018; Hastings et al., 2016).

Recent studies of dynamic structural models permit individuals to leave or re-enter a university in response to new information about the relative desirability of schooling (Altonji et al., 2012; Stange, 2012). Delaying college field specialization is informative in discovering comparative advantages and increasing match quality (Bridet & Leighton, 2015; Malamud, 2010; Patterson et al., 2021). Learning about compatibility with various majors and eliminating informational discrepancies leads to an increase in average student welfare (Arcidiacono et al., 2016; Bordon & Fu, 2015; Bridet & Leighton, 2015). In contrast, mandatory specialization may decrease students' welfare in the form of income growth and turnover (Seah et al., 2020; Silos & Smith, 2015). While option value increases a student's preference for the *college-then-major* choice, uncertainty in benefits and risks associated with the *college-then-major* choice could lower his/her interest in that option.

Conducting field experiments (including lab-in-the-field or survey experiments) is an effective way of learning about the formation of expectation and the link between expectation and behavior (see recent reviews in Fuster & Zafar, 2022; Giustinelli, 2022). In recent years, informational experiments have been increasingly used to study the determinants of students' college major choices, such as earnings (e.g., Conlon, 2021; Ding et al., 2021; Hastings et al., 2015; Wiswall & Zafar, 2015) and exposure to a field of study (Fricke et al., 2018; Patterson et al., 2021). Typically, students' expectations are substantially biased but are malleable with additional information – oftentimes logically updating their beliefs in response to the information provided in experiments (Hastings et al., 2016). Simple information interventions are important for reducing uncertainty about majors and outcomes and can have meaningful impacts on their beliefs and major choices (Patnaik, Wiswall, & Zafar, 2020).

Empirical studies have revealed that informational nudges have heterogeneous effects. While nudging often has positive average effects, the greatest effects often arise for individuals who are affected most by the behavioral barriers—such as lack of self-control, limited attention and cognitive ability, loss aversion, default bias, self- and social-image, social norms, and biased beliefs—that are targeted by a particular intervention (Damgaard & Nielsen, 2018; Dynarski et al., 2022). Interventions may be particularly effective for individuals facing economic or social scarcity (Mullainathan & Shafir, 2013). Those students lack accurate information and have comparatively more information friction problems, which impedes them from making good decisions. For example, the information about returns to education has the largest effects on low-socioeconomic (SES) students, who are more likely to lack such information since they often have less-educated or low-income parents (Damgaard & Nielsen, 2018).

Additionally, students with low SES are more likely to be affected by self-control problems, limited attention, limited cognitive ability, and default bias, therefore, the effects of some interventions are largest for them (Damgaard & Nielsen, 2018; Golsteyn et al., 2014). 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 (Bird, Castleman, Goodman, & Lamberton, 2017; Castleman & Page, 2015). Similarly, an 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 influenced by the wage information in Science, Technology, Engineering, and Management (STEM)-related major applications and admissions since they are less likely to value extrinsic incentives for major choices.

[5] Some US universities are changing from the college-then-major mechanism to college-major mechanism. For example, students have to apply to one college directly at universities like Cornell and the University of Illinois at Urbana/Champaign. Their final major options will be limited to the selected college, and the internal transfer within the university could be difficult.

[6] For example, the information on major selection restrictions may not be found on universities' admission websites or not be online anywhere.

3. Background: Chinese meta-major reforms

The specific institutional context of this paper is the meta-major reforms in China, one of the fundamental mechanism changes in Chinese college-major admissions in recent years. Like many other countries, students in China typically choose their colleges and majors jointly (i.e., *college-major* choice) in the centralized college admissions system. After taking the annual College Entrance Exam, students submit a rank-ordered list of college-major choices to the centralized system and then the system matches each student to at most a college-major based on their exam scores and applications. The recent meta-major reforms cluster certain majors into a larger cohesive bucket. Students can apply to a meta major of a college and declare a specific major among the available options after one or two years of study. These *college-then-major* type reforms aim to consolidate the foundation of both general and major-specific knowledge and provide students with more time to know college majors and their own preference.

The reforms have been mainly implemented in China's selective universities. According to the admission brochures of each university and related statistics, all the 42 most selective "double first-class" construction universities and more than 50% of Project-211 selective universities have implemented the reforms by 2020.[7] Meta-major settings vary across these institutions and generally follow three different admission modes: (1) admission to disciplines (e.g., science); (2) admission to departments or schools (e.g., School of Engineering); (3) admission to honors programs (e.g., "science experimental class"). Among the "double-first-class" universities that lead the meta-major reforms in China, the number of majors included in one meta-major varies from 1 to 30, and 90% of the meta-majors contain 1 to 5 majors. And more than half of these institutions have established a general science or humanities meta-major. Some universities have combined majors with higher ratings and lower ratings, or the popular and unpopular majors into one meta-major. For example, a computer science meta-major also contains other irrelevant majors, like civil engineering and material engineering. This challenges students' ability in acquiring and processing information in the college major application process.

The meta-major reforms as a form of *college-then-major* mechanism are different from the *college-major* mechanism in two primary ways. First, it simplifies students' major choices by reducing the initial number of choices available for college applicants but may increase the complexity of making decisions. In the meta-major reforms, students need to not only obtain information about what majors each meta-major includes but also analyze the benefits and risks of each meta-major before making a deliberate decision. It is usually more difficult to compare each meta-major than each specific major since the former is a cluster of various majors. Appendix Fig. A.1 provides an example of information that each student can obtain from the official college application guidebook distributed by the provincial Department of Education when applying to colleges and majors. Using this guidebook, students may access information about meta-major names, specific majors, tuition, quota, and the previous admission scores of each university. This information is far from complete. More specific information is needed to be accessed by students and parents to make a well-informed college major choice, such as what courses and training are provided, where graduates get employed, and what the returns to majors are. If students only rely on the guidebook for decision-making, they are very likely to face information frictions, which are especially common among disadvantaged students (Ye, 2023).

Second, the reforms postpone the timing of the major declaration until after the freshman or sophomore year, but students still face a lot of uncertainties. Similar to the conventional *college-then-major* choice (e.g., in the United States), students in those meta-majors can declare a major in a specific discipline after studying the general courses related to their meta-major for one or two years. As quota are often limited in each major, the final major choice is based on a two-way selection mechanism determined both by the schools' admission requirements and policy and students' interests and expertise, which differs across universities.

The assignment mechanism is quite complex. Students propose their preferred majors under their meta-major first and then they are assigned to certain majors according to their preference and some criteria, such as their College Entrance Examination (CEE) scores, academic performance in the first or second year after enrollment, and/or scores of tests specifically designed for assignment. Usually, the criteria are ambiguous, causing the students to face greater uncertainties in their initial meta-major application and their final major choices.

We conducted a comprehensive collection and review of the policies for all colleges and were unable to identify accurate assignment mechanisms for nearly all the colleges. For example, Appendix Fig. A.2 presents the relevant information from a top-5 university in China: "*Major assignment will be carried out within the platform and college (meta-major) based on student preference, college entrance examination scores, tests scores in college, and other regulations.*" However, how the different test scores are weighed and which matching mechanism would be used, are not mentioned. Even after gaining this information, students would not be able to accurately predict their probabilities of being assigned to different specific majors. Furthermore, one potential risk is that students may be under significant academic pressure in the first one or two year of college to meet certain criteria, and they may finally be assigned to a less-preferred major if they could not meet the criteria, even though they could have entered a preferred major in the *college-major* choice mechanism.

In summary, the meta-major reforms in China are like a double-edged sword. They may address problems in the *college-then-major* mechanism, but they may also bring new challenges. Various social media reports over years have shown that students and their families generally do not have sufficient information on both benefits and risks of the meta-majors. However, there is still a lack of empirical evidence on such information frictions, particularly how the various types of information about meta-majors affect students' preferences and behaviors.

4. Methodology

4.1. Experimental design

We designed and implemented a field experiment with Chinese college applicants 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. This sample, designed to be nationally representative and implemented through random sampling, was purposefully restricted to students who participated in the National College Entrance Examination (NCEE) and were eligible for four-year undergraduate college admissions.[8] The survey was conducted after those students submitted their college-major applications and did not affect their actual applications or admissions.

[7] The "double first-class" construction universities are the most elite institutions of Chinese tertiary education, representing the top 5% of overall universities and colleges in China. Project-211 is a broader group of key universities in the 21st Century, which includes 112 highly selective universities.

[8] The survey was conducted by the CSEDS annually to monitor the consequences of college-major admissions and participants were sampled randomly. While we do not access the confidential data on the sampling process and no national statistics on student characteristics, we compare the sample to available statistics in the next section and confirm the representativeness of the sample.

Table 1
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]	
Science-track	0.620	0.631	0.632	0.622	0.702
	[0.486]	[0.483]	[0.482]	[0.485]	
NCEE score	491	495	494	493	0.840
	[179]	[176]	[178]	[179]	
NCEE 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 interests	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]	
Information source: self	0.776	0.759	0.748	0.765	0.215
	[0.417]	[0.427]	[0.434]	[0.424]	
Information source: professional counseling	0.102	0.102	0.113	0.112	0.109
	[0.302]	[0.302]	[0.317]	[0.315]	
Information source: others	0.764	0.771	0.776	0.777	0.235
	[0.425]	[0.421]	[0.417]	[0.416]	
Career education in high school: college application	0.288	0.298	0.295	0.292	0.835
	[0.453]	[0.457]	[0.456]	[0.455]	
Career education in high school: 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	

Note. 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.

Instead, we measured students' major choice preferences as the main outcome.

In the experimental module of the survey, students were asked to declare their willingness to choose a meta-major over a traditional college major after being randomly presented with one of the following four types of information:

- **Control**: only the name of the meta-major, no additional information.
- **T1 (list of majors)**: the name of the meta-major and the specific majors included in the meta-major.
- **T2 (list of majors + benefits)**: the name of the meta-major, the specific majors offered by the meta-major and the learning benefits of the meta-major.
- **T3 (list of majors + assignment mechanisms)**: the name of the meta-major, the specific majors included in the meta-major, and the assignment mechanism and uncertainties of major declaration in the meta-major.

Since students in the science and humanities tracks in the NCEE are eligible for different meta-majors, we created a slightly different version for students in each track. Appendix Table B.1 details the intervention components. The **control group** information applies to the hypothetical scenario where students are careless and effortless in college-major applications that they only make their uninformed applications based on the name of the meta major. The **T1 group** closely resembles the status quo scenario with the most common information that students can access and speaks to the natural experimental results reported by Li, Ma, Ye, & Zhu, 2022 and Kang et al. (2022). The **T2 group** makes the information on the learning benefits of choosing a meta-major more salient and potentially increases students' interests and preferences. As discussed before, only very well-informed students understand the differences in option values of *college-major* choice and *college-then-major* choice. The major assignment mechanism information in the **T3 group** is the least accessible and often overlooked by students, which is also complicated because the mechanisms vary greatly across colleges. Whether students respond positively or negatively to the assignment mechanism information (T3) is *ex ante* ambiguous.

All the information in those treatment groups, including the majors included in a meta-major and the descriptions, was compiled verbatim from the official texts from a set of colleges in 2020. For simplicity, we did not list any specific colleges in the hypothetical scenarios but focused on major choices only. In real college applications, students face an even more complicated and strategic decision-making procedure. They not only consider the tradeoff between a meta-major and a specific major but also consider the tradeoff between a meta-major in college A and a specific major in college B. The experiment presented in this paper was designed to understand exclusively the information frictions on their major preferences between *college-major* choice and *college-then-major* choice. Future work can examine the substitution or complementation effects between colleges and majors in both centralized and decentralized admissions systems.

4.2. Empirical strategy

We examined how students' preferences for the meta-major vary in response to different information on the characteristics of the meta-major. The following linear probability model was used to estimate the effects of the three treatment conditions:

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

where Y_{ij} is the willingness to apply to a meta-major of student i in high school j; T_{kij} are the binary treatment indicators ($k = 1, 2, 3$), referring to the information interventions on the major list, benefits, and assignment mechanisms, respectively; β_k indicate the average treatment effects of the interventions; X_{ij} is a vector of pre-treatment student characteristics, including gender, NCEE scores, only-child status, hukou, parental educational attainment, major preference, information sufficiency and sources, and the content of high school counseling; δ_j are the high school fixed effects and ε_{ij} is the error term.[9] All standard errors are clustered at the high school level.

We then estimated the heterogeneous treatment effects using linear interactions between the treatment indicator and individual

[9] In the Hukou system, the citizen was classified as rural or urban based on the location of origin. In the survey, students were asked to report whether they prefer to choose a major of interest, a popular major, jointly consider a college and a major, or prefer prestigious universities (multiple choice questions). One question in the survey is about whether students have sufficient knowledge of universities and majors, and their main sources of information: self, counseling institute, teachers, parents, relatives, and friends (multiple choice questions). Students were also asked to report the main content of high school counseling, such as subject selection, college application, and introduction to universities (multiple choice questions).

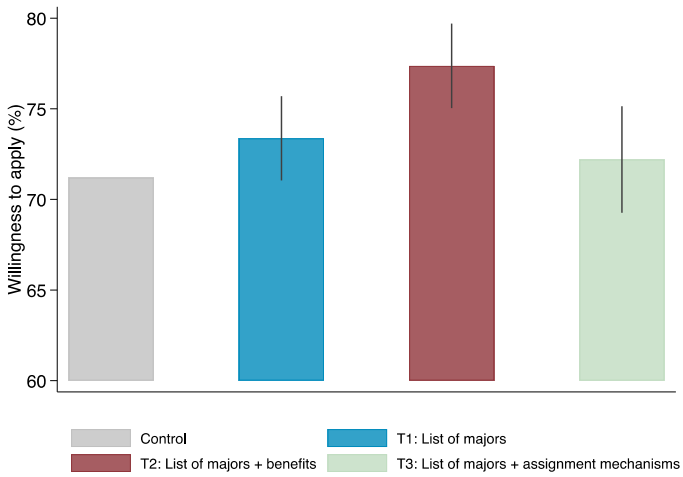

Fig. 1. Mean difference in the willingness to apply across control and treatment groups.
Note. This figure shows the means of the full-sample students' willingness to apply to a meta-major across control and treatment groups with 95% confidence intervals. Students' willingness to apply is statistically significantly higher for the treatment group T2.

Table 2
Treatment effects of the informational interventions on students' willingness to apply to a meta-major.

Sample	All students			Science track	Humanities track
	(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 (List of majors)	0.022*	0.016	0.016	-0.008	0.031
	(0.013)	(0.014)	(0.014)	(0.016)	(0.025)
T2 (List of majors + Benefits)	0.062***	0.060***	0.059***	0.044***	0.062***
	(0.013)	(0.014)	(0.014)	(0.017)	(0.021)
T3 (List of majors + Assignment mechanisms)	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	No	Yes	Yes	Yes	Yes
High school fixed effects	No	No	Yes	Yes	Yes
Observations	11,424	11,424	11,424	7,101	4,323

Note. The table reports the OLS regression results of the average treatment effects of meta-major information on the willingness to apply to a meta-major. The standard deviation of the outcome in the control group is reported in square brackets. The p-values of pairwise tests for equal coefficients between each pair of treatments are in curly brackets. Control variables are summarized in Table 1. Robust standard errors clustered at the high school level are in parentheses. ***, ** and * indicate statistical significance levels of 0.01, 0.05 and 0.10, respectively. level.

characteristics. We were interested in the heterogeneous effects on students with different socioeconomic backgrounds, information resources, major preferences, and risk attitudes. We hypothesized that students who were more constrained by behavioral barriers and lack of information and resources would respond more to the additional information in the experiment, based on the existing literature on informational nudging and our pre-experiment exploratory qualitative analysis.

5. Results

5.1. Balance test

The randomization was successful: the four groups were balanced in their observable student characteristics, given the student-level randomization automatically implemented by the survey platform algorithms. 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. As indicated in Table 1, both the individual tests and the joint test show no statistically significant differences in the students' characteristics across the groups. The joint F test p-value from a multinomial logistic regression is 0.861, indicating that the observed students' characteristics cannot predict the treatment assignment.

We used several available statistics to assess the representativeness of our survey sample to the national student population. First, the survey sample is representative of the student population in terms of gender. Based on China Educational Statistics Yearbook, the proportion of female undergraduate students at regular higher education institutions is 53.70%, and the proportion is 50.41% at regular senior secondary schools in 2020. Second, the national ratio of science-track to humanities-track students is about 3:2, which is close to the ratio of our sample. In addition, the proportions of students with rural hukou and with parents having college education are close to those of a nationally representative sample of undergraduate students (Jia & Li, 2021).

Large information frictions existed among such highly academically prepared students. Our sample limits to students who were eligible for four-year college admissions, accounting for about 40% of all the academic high school graduates and 22% of the birth cohort in 2002. However, fewer than 60% reported having sufficient information on colleges and majors after they submitted their applications. Several factors contribute to this lack of critical information for college-major applications: fewer than 30% of students reported to have received career education on college applications in high school; most of them searched for information by themselves or with help from non-experts (e.g., family members, friends, and teachers); only about 10% of students received help from professional counseling.

In terms of college and major preferences, students reported heterogeneous and diverse preferences. While about half of the sampled students chose majors of their interests, 17% of the students were attracted by "popular" majors that may not be of their interests. Half of the students traded their preferences between colleges and majors that they chose to attend a preferred college with a less preferred major, or vice versa. Because of information frictions, students' college and major preferences were quite malleable with additional informational nudging.

5.2. Average treatment effects

Our outcome is students' willingness to apply to a meta-major measured in the survey. Fig. 1 shows the mean of students' willingness to apply to a meta-major by treatment status. As expected, providing information on the potential learning benefits of meta-majors (T2) significantly increased students' willingness to apply, whereas providing information on the major list or the assignment mechanism had smaller, statistically insignificant positive impacts. The results were not driven by the two different settings in either the science track or the humanities track. Appendix C presents similar results separately for the high school academic tracks.

Table 2 reports the estimation results of the linear probability model (Eq. (1)). Columns (1) – (3) show the results for all students, and

Table 3
Heterogeneity in the treatment effects by socioeconomic background.

Heterogeneity group groups	Socioeconomic background		
	Advantaged (1)	Disadvantaged (2)	Gap (3)
Control	0.724	0.700	
	[0.447]	[0.459]	
T1 (List of majors)	-0.006	0.041**	-0.047**
	(0.018)	(0.017)	(0.022)
T2 (Benefits)	0.050***	0.071***	-0.021
	(0.016)	(0.020)	(0.025)
T3 (Assignment mechanisms)	0.007	0.016	-0.009
	(0.019)	(0.020)	(0.025)
Observations	5,736	5,688	

Note. Students' socioeconomic background was measured by their hukou type (urban or rural), parental educational attainment (second-generation or first-generation), and high school type (selective or not). We used principal component analysis to compute a factor and dichotomized students based on factor scores: students with factor scores higher than 0 as having an advantaged background, and the others as disadvantaged. The gap in treatment effects across different groups is measured using the coefficients of interactions between the treatment and group indicators, as shown in Column (3). All the regressions include covariates and province fixed effects. Robust standard errors clustered at the high school level are in parentheses. ***, ** and * indicate statistical significance levels of 0.01, 0.05 and 0.10, respectively.

Table 4
Heterogeneity in the treatment effects by information friction status.

Heterogeneity group groups	Information friction		
	Rich information (1)	Limited information (2)	Gap (3)
Control	0.724	0.697	
	[0.447]	[0.460]	
T1 (List of majors)	-0.016	0.047***	-0.064**
	(0.020)	(0.017)	(0.025)
T2 (Benefits)	0.027	0.091***	-0.064**
	(0.018)	(0.019)	(0.026)
T3 (Assignment mechanisms)	-0.032*	0.052***	-0.084***
	(0.019)	(0.019)	(0.024)
Observations	6,307	5,117	

Note. Students' information friction was measured by their self-reported information sufficiency, including whether they had sufficient information on colleges and majors. We used principal component analysis to compute a factor and dichotomized students based on factor scores: students with factor scores higher than 0 as having rich information, and the others as having limited information. The gap in treatment effects across different groups is measured using the coefficients of interactions between the treatment and group indicators, as shown in Column (3). All the regressions include covariates and province fixed effects. Robust standard errors clustered at the high school level are in parentheses. ***, ** and * indicate statistical significance levels of 0.01, 0.05 and 0.10, respectively.

columns (4) and (5) report the results for the science-track and humanities-track students, respectively. Column (1) contains the three treatment dummies, Column (2) adds student pre-treatment covariates, and Columns (3) - (5) add high school fixed effects. The first two rows report the control group's mean and standard deviation of the willingness to apply to a meta-major for reference.

Without additional information, 71.2% of all students in the control group were willing to apply to a meta-major just by knowing the name of the meta-major. Students in the humanities track had a higher interest (74.1%) than those in the science track (69.4%). We found that providing information on the benefits of a meta-major (T2) significantly increased students' willingness to apply. After controlling for covariates and high school fixed effects, students who were presented with the benefits information were 6 percentage points more likely to apply to a meta major than those in the control group, which is a 8 percent increase

Table 5
Heterogeneity in the treatment effects by college-major preference.

Heterogeneity group groups	College-major preference		
	Clear (1)	Unclear (2)	Gap (3)
Control	0.709	0.715	
	[0.454]	[0.452]	
T1 (List of majors)	-0.008	0.040**	-0.048**
	(0.017)	(0.018)	(0.022)
T2 (Benefits)	0.044**	0.075***	-0.031
	(0.018)	(0.016)	(0.022)
T3 (Assignment mechanisms)	-0.022	0.043*	-0.065**
	(0.017)	(0.022)	(0.026)
Observations	5,571	5,853	

Note. Students' major preference was measured by whether they preferred majors of interests, which indicates that they had a clear major preference. The gap in treatment effects across different groups is measured using the coefficients of interactions between the treatment and group indicators, as shown in Column (3). All the regressions include covariates and province fixed effects. Robust standard errors clustered at the high school level are in parentheses. ***, ** and * indicate statistical significance levels of 0.01, 0.05 and 0.10, respectively.

from the control mean. Given the light-touch nature of the nudge information, the estimated treatment effect of T2 is sizable (DellaVigna & Linos, 2022). Specifically, science-track students who were presented with the benefit information were 4.4 percentage points more likely to apply to a STEM meta-major and humanities-track students were 6.2 percentage points more likely to apply to a humanity meta-major than their respective counterparts in the control group.

We did not find statistically significant impacts of the information of the specific list of majors (T1) or assignment mechanisms (T3) on students' preferences for meta-majors. However, we observed some differences by academic tracks. Highlighting the majors included in a meta-major and the risks of being assigned to an unpopular major is more salient for students in the science track and decreased their willingness to apply to a science meta-major. In contrast, the students in the humanities track were approximately three percentage points more likely to apply to a humanity meta-major when receiving information on the list of majors included in a meta-major or assignment mechanisms. However, these differences were not statistically significant. This between-subject difference is likely due to that there are several "sink-hole majors" included in the science meta-major that many students disfavored, but the popularity within humanities majors is less extreme.[10]

5.3. Heterogeneity in the treatment effects

We then examined how different students responded to the informational interventions differently based on their different degrees of information frictions and heterogeneous preferences, including four categories: (1) socioeconomic background, (2) information frictions, (3) college major preference, and (4) risk preference and gender. We estimated the heterogeneous treatment effects using linear interaction models. We identified the main effects for the two groups separately within each category and the gap in the treatment effects between the two groups. Table 3-6 summarize the main results for these four categories.

Socioeconomic background. Table 3 shows that students from disadvantaged backgrounds were more likely to respond to additional

[10] One of the motivations that colleges favor the meta major reforms is that they could cluster popular and unpopular majors into a meta major and thus increase the attractiveness of those unpopular majors, and many colleges have done so. Students who did not pay enough attention to the major information (T1) or the assignment mechanism information (T3) often reported regretting their college-major choices. We present more discussions in Section 6.

Table 6
Heterogeneity in the treatment effects by risk preference.

Heterogeneity group groups	Risk attitude			Gender		
	Risk averse (1)	Risk taking (2)	Gap (3)	Female (4)	Male (5)	Gap (6)
Control	0.704	0.752		0.690	0.745	
	[0.457]	[0.433]		[0.463]	[0.436]	
T1	-0.003	0.106***	-0.109***	-0.009	0.053***	-0.062**
	(0.017)	(0.032)	(0.038)	(0.018)	(0.019)	(0.026)
T2	0.033*	0.182***	-0.149***	0.048**	0.078***	-0.030
	(0.017)	(0.032)	(0.039)	(0.019)	(0.014)	(0.022)
T3	-0.008	0.097***	-0.105***	-0.009	0.040**	-0.049*
	(0.018)	(0.034)	(0.040)	(0.020)	(0.018)	(0.025)
Observations	9,358	2,066		6,650	4,774	

Note. Students' risk preference was measured by whether students chose more risky college-major options in their college applications. The gap in treatment effects across different groups is measured using the coefficients of interactions between the treatment and group indicators, as shown in Column (3). All the regressions include covariates and province fixed effects. Robust standard errors clustered at the high school level are in parentheses. ***, ** and * indicate statistical significance levels of 0.01, 0.05 and 0.10, respectively.


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 (Yao Class)】

[03]-[05] omitted

B. Major list, quota, tuition, and specific majors in Form II (admissions vacancy for the current year)

Fig. A.1. Admission instructions of Tsinghua University.
Note. The two screenshots are from the official college application guidebook in 2020 in Chongqing. Each province uses nearly identical format and information. The named classes (e.g., Xuesen Qian Mechanics Class, Computer Science Experimental Class, Chi-Chih Yao Class) are a form of advertisement that the top colleges use to highlight the benefits of the meta majors.

information and to change their meta-major preferences. Those disadvantaged students also largely responded to the simple information on the list of majors included in a meta-major, indicating severer information friction problems. Students' socioeconomic status is constructed based on their hukou type, parental education, and high school type. These variables correlated with students' *objective* access to college choice information (Damgaard & Nielsen, 2018). Itemized results are presented in Appendix Table D.1, showing that students with rural hukou, first-generation students, or students who graduated from non-selective high schools responded more to the additional information.

Information frictions. All three types of additional information provided in the experiment, even the simple information on which majors are included in a meta major, had substantial effects on students who *subjectively* reported having limited access to accurate college-major choice information (Table 4). We also used the content of high school career education and self-reported information sources to assess students' information access (see the supplemental results in

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.

Fig. A.2. Admissions prospectus of Shanghai Jiaotong University (assignment mechanism).
Note. This screenshot shows the information relevant to meta major assignment mechanism from a university's official Admissions Prospectus. Source: https://gk.sjtu.edu.cn/Data/View/2861

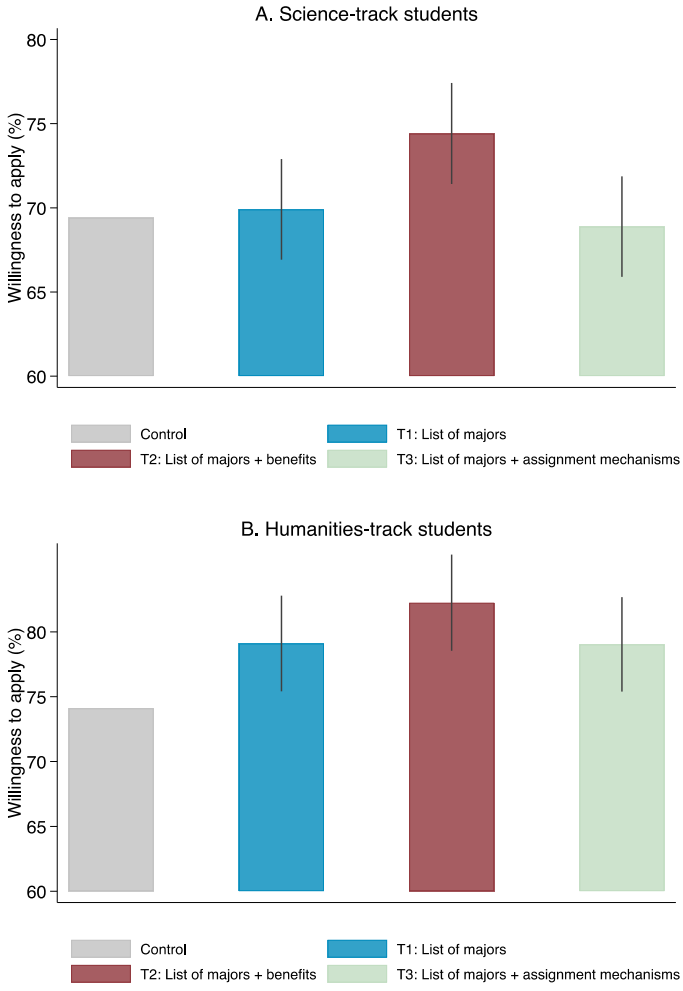

Fig. B.1. Treatment effects by academic track in the College Entrance Exam.

Appendix Table D.2). Specifically, when students could not get access to sufficient information on colleges and majors and when high schools did not provide the necessary guidance in career education, students were more likely to be affected by the extra information. Moreover, students who took the initiative to collect information were less likely to trust and process additional information.

Recall the first heterogeneity perspective, insufficient information and a lack of guidance may be the primary mechanisms through which students' background affects their behaviors and the inequality in college major choice. In our sample, students' socioeconomic background was highly correlated with their *subjective* evaluation of access to college choice information. In absence of the information provision as described in this paper, the meta-major reforms may have intensified the inequality in college major choice. The long-term impacts of meta-major reforms between advantaged and disadvantaged students need further investigation.

College-major preference. Table 5 shows that students with clear college major preferences – i.e., they knew which major they would pursue in college before college applications – were less likely to be affected by the information provided in the experiment. The finding is consistent with prior literature in that information intervention has the largest effect on students with less-developed college plans (Castleman & Page, 2015). This result highlights the importance of providing information and guidance early on to help students form their college major choice preferences. However, even among those students who reported clear college major preferences, receiving information about the benefits of meta-majors still largely changed their preferences.

Risk preference. Since the meta-major reforms 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 (Table 6 Columns 1–3). 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 popular majors in the *college-major* choice mechanism.

We also find large gender gaps that may correlate with heterogeneous risk preferences. Male students responded positively to all types of information, while female students only responded to the benefits information (Table 6 Columns 4–6). The average null effect of specific major and assignment mechanisms information on students application is masked by the significant gender gap in the treatment effects. Specifically, while males responded more positively to all types of information, female students responded more negatively. The positive effect of the assignment mechanisms information for male students might be because they tend to be more confident about their ability or less risk averse (Patnaik, Wiswall, & Zafar, 2020; Reuben et al., 2017; Wiswall & Zafar, 2015).

6. Discussions with supplemental text data

The experiment presented above shows that students had information frictions in their meta-major choices. When being provided with additional information, their existing degrees of information frictions and heterogeneous preferences affected how they responded to various information on meta majors. In this section, we further discuss the potential mechanisms of those experimental results from three perspectives: imperfect information (T1), assignment mechanisms (T3), and attraction of benefits (T2).

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 zhihu.com, a popular Chinese online discussion board similar to quora.com. The data from zhihu.com have been effectively used by researchers to analyze other higher education

Table B.1
Information intervention components.

Randomization group	Content	Treatment information *Science track*	*Humanities track*
		Post-Treatment Question: *Engineering meta major is an important reform of college admissions. Please indicate whether you would like to choose a science meta major or not.*	Post-Treatment Question: *Humanities meta major is an important reform of college admissions. Please indicate whether you would like to choose a humanities meta major or not.*
Control	name of meta major	Engineering meta major	Humanities meta major
T1: List of majors	name of meta major + the specific majors offered by the meta major	The engineering meta major 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 humanities meta major includes the following specific majors: Chinese, foreign languages, history, philosophy, archaeology, etc.
T2: List of majors +Benefits	name of meta major + the specific majors offered by the meta major + the benefits of the meta major	Given 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 engineering meta major 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 humanities meta major 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: List of majors + Assignment mechanisms	name of meta major + the specific majors offered by the meta major + the assignment mechanism of the meta major	The engineering meta major 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 a specific major. 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 provisions, however, there is no guarantee that everyone can enter a popular major.	The humanities meta major 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 a specific major. 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 provisions, however, there is no guarantee that everyone can enter a popular major.

Note. The majors included in each meta major and the introductory descriptions were compiled verbatim from official texts of several colleges.

policies (Eble & Hu, 2022). We collected open-ended questions and responses related to the meta-major reforms (as of August 31, 2021) and then coded the data into the domains or topic areas to characterize the common patterns.[11] The text data richly characterize how students perceive meta-majors and how they could influence their college choice. A discussion on the meta-majors, mostly from college students in 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

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

Table D.1
Heterogeneity in the treatment effects: socioeconomic background.

Heterogeneity group groups	Socioeconomic background Urban hukou (1)	Rural hukou (2)	Gap (3)	Second-generation (4)	First-generation (5)	Gap (6)	Selective high school (7)	Non-selective high school (8)	Gap (9)
Control	0.725	0.701		0.728	0.704		0.726	0.696	
	[0.447]	[0.458]		[0.445]	[0.457]		[0.446]	[0.460]	
T1	−0.010	0.040**	−0.050**	−0.002	0.027*	−0.028	0.002	0.035**	−0.033
	(0.019)	(0.016)	(0.024)	(0.020)	(0.016)	(0.024)	(0.022)	(0.016)	(0.027)
T2	0.047***	0.072***	−0.025	0.043**	0.070***	−0.027	0.053***	0.070***	−0.017
	(0.017)	(0.019)	(0.024)	(0.019)	(0.018)	(0.027)	(0.019)	(0.018)	(0.025)
T3	−0.001	0.022	−0.023	0.002	0.016	−0.015	0.002	0.022	−0.020
	(0.021)	(0.018)	(0.026)	(0.022)	(0.017)	(0.026)	(0.020)	(0.019)	(0.026)
Observations	5,151	6,273		3,825	7,599		6,076	5,348	

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

conducted supplemental case studies, which included focus group interviews with 22 high school graduates during the college application seasons in 2020 and 2021 and six college students in meta-majors. The full themes and summaries are presented in Appendix Table E.1.

6.1. Combination of college majors in meta-major and imperfect information

In the experimental setting, students' responses were not largely altered by the information of specific majors (T1) offered in a meta-major, which is the most ubiquitously (likely the only) accessible information for all the students in their college-major applications. The null effect of this information on students' willingness to apply to a meta-major suggests that the current information available to students was not sufficient to change their college-major choice preferences. This explains the overall insignificant change in the college-major choice behavior in the early years of implementing the *college-then-major* reforms founded by Li, Ma, Ye, & Zhu, 2022 and Kang et al. (2022) using administrative data on Chinese college entrance exam scores.

The insignificant effect of the information on specific majors (T1) may be also because both popular and unpopular majors were included in the same meta-major, providing a mix of positive and negative information shocks to students. This is also what we observed in the real setting of the *college-then-major* reforms. As indicated by the text data we obtained from zhihu.com, Some respondents (college students) critiqued the unreasonable setting of majors and courses in meta-majors. In particular, many colleges tend to combine popular and unpopular majors into a meta-major to increase the attractions of unpopular majors to students. 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.*"

Moreover, the fields of study within a meta major may be too broad for students to focus their time and efforts on the fields that they have most interests and passion in, and students in meta-majors seemed to have unsatisfying experiences: "*Students are forced to explore and study 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 college students in meta-major talked about the heavy study burden 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.*"

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. Therefore, the information on specific majors has an insignificant effect on students' intention to apply on average. However, students who have severe information friction problems (e.g., unaware of majors included in a meta-major) respond favorably to such information.

6.2. Assignment mechanisms: a mix of opportunities and risks

The *ex-ante* effect of the information on the assignment mechanisms (T3) is mixed. Postponing the final major choice by more than one year after their college enrollment was beneficial for students who needed more time to learn and discover their interests and advantages before making decisions. One of the respondents from zhihu.com noted that "*The meta major reforms helps students to choose their majors rationally after learning more about the characteristics of each major.*" However, the delay of major decisions may impose risks of entering less-favored majors. The major assignment of meta majors also places 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 the competition intensifies,* students *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 even before the declaration of their final major choice. Understanding the complicated assignment mechanism may be a challenge for students, as one noted as follows: "*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 in colleges (Damgaard & Nielsen, 2020). On the online discussion board, people jokingly commented on the "Pareto principle of meta-majors," that "*80% of the students believe that they will be in the top 20% of the class.*"

Students with different perceptions of the assignment mechanisms may respond differently to the corresponding information intervention (T3). Because of the barriers to accessing the relevant information or inattention, many students did not consider assignment mechanisms when applying for a meta-major. Consequently, the information produced overall insignificant effects but particularly, substantially heterogeneous effects between risk-loving and risk-averse students.

6.3. Attraction of benefits: the most influential information

Recall the experimental results, the most salient effects came from the benefits information (T2). However, students had limited access to and knowledge of these learning benefits of choosing a meta-major. Typically, college information sessions, recruitment materials, or social media provided such information. However, not all students could

Table D.2
Heterogeneity in the treatment effects: sources and quantity of information.

Heterogeneity group	Information sufficiency						Career education			Information sources		
Groups	Sufficient knowledge of college	Insufficient	Gap	Sufficient knowledge of major	Insufficient	Gap	College introduction and application	Other contents	Gap	Self	Other	Gap
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Control	0.722	0.699		0.720	0.702		0.762	0.688		0.714	0.705	
	[0.448]	[0.459]		[0.449]	[0.457]		[0.426]	[0.464]		[0.452]	[0.456]	
T1	−0.022	0.067***	−0.089***	−0.013	0.053***	−0.067**	−0.005	0.029**	−0.034	−0.009	0.116***	−0.125***
	(0.017)	(0.016)	(0.020)	(0.021)	(0.016)	(0.027)	(0.027)	(0.013)	(0.027)	(0.015)	(0.026)	(0.028)
T2	0.028*	0.101***	−0.074***	0.037*	0.088***	−0.052*	0.034	0.074***	−0.040	0.042***	0.128***	−0.086***
	(0.015)	(0.019)	(0.022)	(0.020)	(0.018)	(0.027)	(0.032)	(0.014)	(0.037)	(0.016)	(0.024)	(0.030)
T3	−0.026	0.059***	−0.085***	−0.021	0.050***	−0.072***	0.001	0.017	−0.016	−0.014	0.106***	−0.120***
	(0.016)	(0.020)	(0.022)	(0.019)	(0.019)	(0.024)	(0.024)	(0.015)	(0.024)	(0.016)	(0.034)	(0.038)
Observations	6,460	4,964		6,181	5,243		3,826	7,598		8,644	2,780	

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

Table E.1
Student perceptions of meta major reform.

Theme	Summary of quotes
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 of the students do not want to waste a year on things that are not relevant to their final major.
Benefits	The meta major reforms help 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, students are under great pressure and have to constantly improve their competitiveness.
Recruitment strategy	Universities benefit from the meta major reforms 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 reforms 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 is assigned and they meet 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.

access this information, even though it was freely accessible. Some students may intentionally or unintentionally ignore or forget such information due to behavioral inattention (Damgaard & Nielsen, 2020). In line with our field observations and policy reviews, information frictions affect students' (especially disadvantaged students) understanding of the benefits and costs of choosing a meta-major. Consequently, students' decision-making was not naturally influenced by the reforms, as supposed due to a lack of accurate information on the differences in learning benefits between *college-major* choice and *college-then-major* choice. Additionally, given the complex designs of college-major admissions system in China, information about meta-majors and the relevant benefits are not often easy to process for students and their families without guidance from official and reliable sources. Our experimental results on T2 demonstrate the power of targeting the primary psychological

motivation in increasing students' college-major preferences for specific majors (e.g., meta majors in our case).

7. Conclusion

In this paper, we provide the first randomized experimental evidence on the impacts of *college-major* to *college-then-major* reforms on students' college-major choices. With a nationally representative sample of 12,038 high school graduates, we conducted a randomized informational experiment on the students' college-major choice by providing individuals with different information components about meta-majors, a typical form of *college-then-major* choice. The experimental results show that providing information on the benefits significantly increased students' willingness to apply to meta-majors by about 6 percentage points (versus the control mean of 71.2%); however, information about the specific majors and assignment mechanisms did not substantially affect their meta-major preferences. 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, combined with qualitative evidence, we discussed the potential mechanisms of experimental results in terms of imperfect information, assignment mechanisms, and attraction of benefits.

In college-major applications, the meta-major reforms 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 with more time at a low switching cost. However, under the meta-major policy, students face the challenges of imperfect information about majors, curriculum settings, and assignment mechanisms. Specifically, students are exposed to greater risks and uncertainties in their ultimate major choices, for instance, students with lower academic performance in the first or second year in colleges probably have lower opportunities to be enrolled in their favored majors or popular majors with higher returns according to the assignment mechanism in some colleges. Therefore, students have to collect and analyze information about a meta-major as much as possible when applying to colleges to make a reasonable choice, including both the benefits and risks.

Our paper has important implications for the meta-major reforms, which are increasingly commonly used by many countries that are altering between *college-major* admissions and college-then-major admissions. According to the experimental results, the benefits information on the multi-disciplinary training of a meta-major exerts the most significant impact on students' intent to apply. Our qualitative evidence also shows that students attach great importance to the training mode and course setting, and value the cross-disciplinary and innovative components of meta-majors. However, such information is not widely accessible to all students or students may fail to learn such information in their college-major decisions. Thus, policymakers and university admissions offices should make such information more salient and accessible to attract potential students. More importantly, the curriculum and training mode of meta-majors should remain the top priority in the expansion and deepening of the meta-major reforms. 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, given that meta-major reforms are associated with both opportunities and risks due to the great uncertainties in the assignment mechanisms, universities should also provide more complete and clear information on the assignment rules for each major option to help students make better major choice decisions, which is currently unavailable to most students.

Furthermore, the information has the greatest effect on the individuals who are 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 different options and help them shortlist their potential choices and make the optimal decision.

Our paper provides a better understanding of how students respond to the various kinds of information regarding meta-majors using a randomized lab-in-the-field experiment. However, one of the limitations is that we only assessed students' preferences for meta-majors rather than their actual application behaviors and welfare of choosing meta-majors. Future studies can examine students' actual major choices and longer-term college outcomes. Studies that make further progress on the behavioral barriers in assignment mechanisms of meta-majors will also be important for the designs of college-major choice mechanisms for improving student-major match and college success in different higher education systems.

CRediT authorship contribution statement

Liping Ma: Investigation, Project administration, Writing – review & editing. **Xin Li:** Methodology, Formal analysis, Writing – original draft, Writing – review & editing. **Qiong Zhu:** Writing – review & editing. **Xiaoyang Ye:** Conceptualization, Methodology, Writing – review & editing.

Data availability

The authors do not have permission to share data.

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Appendix A. Information students can obtain from application guidebook

(Appendix A, Figure A1, Figure A2)

Appendix B. Treatment effects

(Figure B1)

Appendix C. Heterogeneity in the treatment effects

(Appendix C, Table D1, Table D2)

Appendix D. Qualitative analysis results

(Appendix D, Table E1)

References

Altonji, J. G. (1993). The demand for and return to education when education outcomes are uncertain. *Journal of Labor Economics, 11*(1), 48–83. Part 1.

Altonji, J. G., Arcidiacono, P., & Maurel, A. (2016). The analysis of field choice in college and graduate school: Determinants and wage effects. *Handbook of the Economics of Education (Vol. 5, pp. 305–396)*. Elsevier.

Altonji, J. G., Blom, E., & Meghir, C. (2012). Heterogeneity in human capital investments: High school curriculum, college major, and careers. *Annual Review of Economics, 4*(1), 185–223.

Arcidiacono, P., Aucejo, E., Maurel, A., & Ransom, T. (2016). *College attrition and the dynamics of information revelation (No. w22325)*. National Bureau of Economic Research.

Bird, K.A., Castleman, B.L., Goodman, J., & Lamberton, C. (2017). Nudging at a national scale: Experimental evidence from a FAFSA completion campaign. NBER Working Paper. 26158. Retrieved from https://www.nber.org/papers/w26158.

Bordon, P., & Fu, C. (2015). College-major choice to college-then-major choice. *The Review of Economic Studies, 82*(4), 1247–1288.

Bridet, L., & Leighton, M. A. (2015). The major decision: Labor market implications of the timing of specialization in college.

Castleman, B. L., & Page, L. C. (2015). Summer nudging: Can personalized text messages and peer mentor outreach increase college going among low-income high school graduates? *Journal of Economic Behavior & Organization, 115*, 144–160.

Che, Y. K., Hahm, D. W., Kim, J., Kim, S. J., & Tercieux, O. (2022). Prestige Seeking in College Application and Major Choice. *Available at SSRN 4309000*.

Chen, Y., & Kesten, O. (2017). Chinese college admissions and school choice reforms: A theoretical analysis. *Journal of Political Economy, 125*(1), 99–139.

Conlon, J. J. (2021). Major malfunction a field experiment correcting undergraduates' beliefs about salaries. *Journal of Human Resources, 56*(3), 922–939.

Damgaard, M. T., & Nielsen, H. S. (2018). Nudging in education. *Economics of Education Review, 64*, 313–342.

Damgaard, M. T., & Nielsen, H. S. (2020). Behavioral economics and nudging in education: Evidence from the field. *The Economics of Education* (pp. 21–35). Academic Press.

DellaVigna, S., & Linos, E. (2022). RCTs to scale: Comprehensive evidence from two nudge units. *Econometrica, 90*(1), 81–116.

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, 62*(8), 1113–1145.

Dynarski, S., Nurshatayeva, A., Page, L. C., & Scott-Clayton, J. (2022). *Addressing non-financial barriers to college access and success: evidence and policy implications (No. w30054)*. National Bureau of Economic Research.

Eble, A., & Hu, F. (2022). Signals, Information, and the Value of College Names. *The Review of Economics and Statistics* (pp. 1–45).

Fricke, H., Grogger, J., & Steinmayr, A. (2018). Exposure to academic fields and college major choice. *Economics of Education Review, 64*, 199–213.

Fuster, A., & Zafar, B. (2022). *Survey experiments on economic expectations (No. w29750)*. National Bureau of Economic Research.

Giustinelli, P. (2022). Expectations in education: Framework, elicitation, and evidence. In *Human Capital and Economic Opportunity Working Group Working Papers*, 2022-026.

Golsteyn, B. H., Grönqvist, H., & Lindahl, L. (2014). Adolescent time preferences predict lifetime outcomes. *The Economic Journal, 124*(580), F739–F761.

Gong, Y., Stinebrickner, R., & Stinebrickner, T. (2022). Marriage, children, and labor supply: Beliefs and outcomes. *Journal of Econometrics, 231*(1), 148–164.

Hastings, J., Neilson, C. A., & Zimmerman, S. D. (2015). *The effects of earnings disclosure on college enrollment decisions (No. w21300)*. National Bureau of Economic Research. https://doi.org/10.26300/btrm-jt20

Hastings, J. S., Neilson, C. A., Ramirez, A., & Zimmerman, S. D. (2016). (Un) informed college and major choice: Evidence from linked survey and administrative data. *Economics of Education Review, 51*, 136–151.

Jia, R., & Li, H. (2021). Just above the exam cutoff score: Elite college admission and wages in China. *Journal of Public Economics, 196*, Article 104371.

Kang, L., Wang, D., Ye, X. Y., & Zhou, Y. (2022). Is late specialization more attractive? Evidence from the meta major reform in China's college. *Working paper*.

Kirkeboen, L. J., Leuven, E., & Mogstad, M. (2016). Field of study, earnings, and self-selection. *The Quarterly Journal of Economics, 131*(3), 1057–1111.

Krussig, T., & Neilson, C. (2021). The rise of centralized choice and assignment mechanism in education markets around the world. *Working paper*.

Li, X., Ma, L., Ye, X., & Zhu, Q. (2022). College-major choice to college-then-major choice: The heterogeneous impacts of late specification reforms on college student composition. Working paper. Retrieved from Annenberg Institute at Brown University: doi:10.26300/d523-te80.

Machado, C., & Szerman, C. (2021). Centralized college admissions and student composition. *Economics of Education Review, 85*, Article 102184.

Malamud, O. (2010). Breadth versus depth: The timing of specialization in higher education. *Labour, 24*(4), 359–390.

Meyer, J., Leuze, K., & Strauss, S. (2021). Individual achievement, person-major fit, or social expectations: Why do students switch majors in German higher education? *Research in Higher Education, 63*, 222–247.

Mullainathan, S., & Shafir, E. (2013). *Scarcity: Why having too little means so much.* Macmillan.

Patnaik, A., Wiswall, M.J., & Zafar, B. (2020). College majors. National Bureau of Economic Research Working Paper Series, w27645. Retrieved from https://www.nber.org/papers/w27645.

Patterson, R. W., Pope, N. G., & Feudo, A. (2021). Timing matters: Evidence from college major decisions. *Journal of Human Resources*, 0820-11127R1.

Payne, J. W. (1976). Task complexity and contingent processing in decision making: An information search and protocol analysis. *Organizational Behavior and Human Performance, 16*(2), 366–387.

Reuben, E., Wiswall, M., & Zafar, B. (2017). Preferences and biases in educational choices and labour market expectations: Shrinking the black box of gender. *The Economic Journal, 127*(604), 2153–2186.

Seah, K. K., Pan, J., & Tan, P. L. (2020). Breadth of university curriculum and labor market outcomes. *Labour Economics, 65*, Article 101873.

Silos, P., & Smith, E. (2015). Human capital portfolios. *Review of Economic Dynamics, 18*(3), 635–652.

Stange, K. M. (2012). An empirical investigation of the option value of college enrollment. *American Economic Journal: Applied Economics, 4*(1), 49–84.

Stinebrickner, T., & Stinebrickner, R. (2012). Learning about academic ability and the college dropout decision. *Journal of Labor Economics, 30*(4), 707–748.

Wiswall, M., & Zafar, B. (2015). Determinants of college major choice: Identification using an information experiment. *The Review of Economic Studies, 82*(2), 791–824.

Ye, X. (2023). Improving College Choice in Centralized Admissions: Experimental Evidence on the Importance of Precise Predictions. *Education Finance and Policy*, 1–75.