College Admission Concerns and Field Choice*

Solomon Gofere†

November 15, 2022

[Click Here for the Latest Version]

[Job Market Paper]

Abstract

This paper studies how college admission selectivity affects the college field choices of students in a centralized, field-specific admission system. The study leverages a policy reform in Ethiopia that increased the share of college seats in public universities allocated to STEM fields by 20 percentage points. The reform resulted in a substantial decrease in the admission selectivity of STEM fields. Using a reduced form specification, I show that students are 24 percentage points more likely to choose a pre-college STEM track post-reform. The field choice response is heterogeneous: academically marginal students are significantly more likely to switch to STEM relative to infra-marginal students. Further, I show that the reform induced a positive selection on field-specific skills: those induced to choose the STEM track are relatively better in skills valued more in STEM fields than those who choose to remain in the non-STEM track. This sorting pattern resulted in a significant change in the peer quality of the pre-college academic tracks that is consistent with the predictions of a Roy model in which STEM is the most valued field, and skills are positively correlated. The results imply that admission concerns play a significant role in students' college field choices. However, students do not naively sort into less selective college fields. The choices they make are consistent with their relative position in the distribution of multi-dimensional skills. This indicates that students sometimes make more informed and rational choices than the existing literature suggests.

Keywords: Field Choice, College Admission Concerns, Selection on Field Specific Skills
JEL Codes: I23, I26, J01, J24.

*I am indebted to Rodrigo Soares, Cristian Pop-Eleches, and Eric Verhoogen for their guidance. I am also grateful to Miguel Urquiola, Douglas Almond, Sandra Black, Jeffrey Shrader, Jack Willis, Daniel Osgood, and Alex Eble for their valuable comments. I thank the participants of the Development Colloquium and Development Seminar at the Department of Economics, Columbia University, and the participants of the Sustainable Development Colloquium and Sustainable Development Seminar at the School of International and Public Affairs, Columbia University. I have also benefited from discussions with Amanda Awadey, Florian Grosset, Xinming Du, Stephan Thies, Vincent Bagilet, Jesse McDevitt-Irwin, Matt Harrington, Jeremias Huber, Tarikua Erda and many other thoughtful individuals. All errors are my own.

†PhD Candidate, Columbia University, School of International and Public Affairs (SIPA), email: smg2220@columbia.edu

1 Introduction

Many countries and colleges use a college admission rule commonly known as a field-specific admission system.[1] In this admission system, students are directly admitted to a specific college field and attend classes with peers mostly from their field. Therefore, in their college applications, students are required to choose a limited number of fields in which they will be considered for college admission. The latter implies that the applicant's choice of college field determines the pool of applicants she competes against for admission and, therefore, her probability of admission. This, in turn, implies that students face a trade-off in their college field choice. On the one hand, competitive fields have better labor market outcomes (Kirkeboen et al., 2016; Altonji et al., 2012; Arcidiacono, 2004). On the other hand, competitive fields are highly selective, and a student choosing a competitive field faces a higher risk of rejection. This trade-off is likely to be stronger in a centralized admission system where outside options are generally limited.

This trade-off has both theoretical and practical implications. It highlights the potential role of uncertainty in students' human capital investment decisions. The sorting into college fields resulting from college admission concerns also has an implication for the composition of students in different fields. Nonetheless, empirical studies investigating this trade-off are limited. This paper studies the effect of college admission concerns on the field choice behavior of students. Specifically, the study examines the extent to which admission selectivity of college fields affects students' field choice in a centralized, field-specific admission system. The main challenge in estimating this causal effect is the potential effect of confounding variables. This study leverages a college admission policy reform in Ethiopia that changed the ratio of college seats in public universities allocated to the STEM fields and fields in Social Sciences and Humanities (henceforth, Humanities) from 50:50 to 70:30 in favor of STEM fields. The reform is likely to substantially change the admission selectivity of STEM fields vs. fields in the Humanities. The study exploits this sharp and exogenous change in college seat allocation to explore how the admission selectivity of college fields affects students' pre-college academic track choice behavior.

This study also explores the extent to which students' field choices are consistent with their relative skill advantage in different college fields. In contexts where choices and skills interact, economic theory predicts that individuals observed in each sector are selected based on their relative skill advantage in various sectors (Silliman and Virtanen, 2022; Willis and Rosen, 1979; Rosen, 1978; Roy, 1951). These selection models predict that students sort into different college fields based on their field-specific skills. However, whether students sort into college fields according to these predictions depends on the degree to which students understand their relative skill advantage in different fields and its implication for various outcomes, including college admission and college and labor market outcomes. In different settings, studies find that students often are not well-informed and make systematic mistakes in their

[1] For example, China, Japan, Spain, and Turkey use some variants of a field-specific college admission system (Bordon and Fu, 2015). Many colleges in a decentralized higher education market also use a field-specific college admission rule (see, for example, Estevan et al. (2019)).

educational choices (Shorrer and Sóvágó, 2018; Hastings et al., 2016; Zafar, 2013).[2] In this study, I use subject-level academic records of students to study sorting on field-specific skills.

The Ethiopian pre-college program provides an ideal setting to study the effect of college admission concerns on students' college field choices. The Ethiopian pre-college is a two-year academic program offering two specialized academic tracks: the STEM track and the Social Sciences and Humanities (henceforth, the Humanities) track. Students are admitted to the program after scoring above a centrally determined admission cutoff point on a pre-college entrance exam. Admitted students choose one of the two academic tracks without restriction. At the end of the program, students scoring above a track-specific admission cutoff on a college admission exam will be admitted to college fields directly related to their pre-college academic track. The field-specific nature of the admission system implies that there is a college admission advantage to strategic trade-off in the pre-college track choice.[3] Further, the college admission system is highly centralized, and outside options are limited and costly. The latter suggests that the incentive for a strategic trade-off in pre-college track choice is likely substantial. Finally, by redistributing college seats from the Humanities to STEM track students, the reform changes students' perceived probability of college admission in the two academic tracks. On the other hand, the reform is unlikely to affect students' beliefs regarding their likelihood to do well in different college fields.

The analysis leverages this rich setting and proceeds in three steps. First, I study how the policy reform affects admission selectivity in the two pre-college academic tracks. To do this, I compare admission rates in the two pre-college tracks before and after the reform. I exploit the structure of the Ethiopian pre-college program to estimate the short-run and the long-run effects of the reform. The first cohort treated by the policy reform chose their academic track one year before the announcement of the reform. As a result, comparing the admission rates of the pre-reform cohorts to those of the first cohort treated by the reform isolates the short-run effect. The estimate shows that the admission rate in STEM fields increased by 15 percentage points in the short run. This admission advantage in STEM will likely drive more students to choose the pre-college STEM track, potentially driving down the admission rate in STEM fields. To estimate the long-run effect, I compare the admission rate of pre-reform and post-reform cohorts. Despite the permanent increase in the proportion of college seats allocated to the STEM fields, I find no significant admission advantage in the STEM track in the long run. This is consistent with a new long-run equilibrium in which students' response to the reform eliminates any admission advantage in the STEM track.

[2] Studies document that students are often not well-informed about crucial variables necessary for schooling decisions, including earnings and costs related to attending a given college field; they tend to overestimate their future academic performances and often make their enrollment and field choice decisions based on inaccurate information (Attanasio and Kaufmann, 2017; Hastings et al., 2016; Huntington-Klein, 2015; Zafar, 2013). Other studies also show that students make systematic mistakes in their standardized test-taking and college application decisions (Goodman et al., 2020; Pallais, 2015).

[3] In a field-specific admission system, a student's college admission probability depends not only on her academic performance but also on the academic performance of students in her track and the number of college seats available to her track.

Given the short-run college admission advantage in the STEM track, what is the rational response for an average student? To document this point, I estimate a reduced form specification comparing the pre-college track choices of pre-reform and post-reform cohorts. The estimate from this specification shows that, on average, students are 24 percentage points more likely to choose the pre-college STEM track after the policy reform. This estimate is comparable in magnitude to the post-reform increase in the proportion of college seats allocated to the STEM fields. Given that the policy reform is unlikely to change a student's perception of her ability or expected performance, the estimate implies that college admission concerns play an important role in students' college field choices. Most importantly, there is substantial heterogeneity in the response across achievement distribution. Specifically, the post-reform increase in the proportion of students choosing pre-college STEM track is largely driven by the academically marginal (and generally, low-achieving) students. The latter is intuitive, given that a change in admission selectivity of college fields is likely to affect the admission outcomes of marginal students more strongly relative to those of infra-marginal ones.

The validity of the reduced form estimate depends on the comparability of cohorts before and after the reform. Students are admitted to the pre-college program based on standardized criteria comparable across cohorts. Furthermore, a comparison of observable characteristics suggests that cohorts before and after the reform are comparable. Moreover, estimates from cohorts closer to the reform date are consistently similar to the main estimate, suggesting that unobservable trends are unlikely to drive the result. Finally, a local Regression Discontinuity (RD) estimate exploiting a within-cohort variation generated by the pre-college admission threshold shows that the main estimates are robust.[4] There is also a concern that the policy reform will increase pre-college enrollment among those who would not have attended the program absent the reform. The latter biases the reduced form estimate upwards if those induced to attend the program are more likely to choose the STEM track. I study this hypothesis by examining the presence of a sharp increase in the proportion of students who choose to attend the program among those eligible. I find no evidence of differential attendance pattern post-reform.

To better understand students' sorting into different college fields, I study selection on field-specific skills. Those induced to choose the pre-college STEM track, the compliers, are unlikely to be a random draw from the pre-college student population. Therefore, understanding the sorting pattern and the characteristics of the compliers is important for theoretical and policy purposes. The sorting pattern has an implication for the composition of students in different college fields and potentially for the quality of the labor force in the labor market in the long run. In addition, this analysis is informative of the extent to which student choices are informed and consistent with the theoretical predictions of models of self-selection. In this study, I adopt the approach suggested by Abadie (2003) and Angrist and

[4] This RD design compares the field choices of students near the pre-college admission cutoff points. Among cohorts immediately before the reform, those scoring above the pre-college admission cutoff make their track choice before the announcement of the reform. In contrast, those below the cutoff will be forced to wait one more year to re-take the entrance exam and hence, make their track choice after the announcement of the reform.

Imbens (1995) to estimate the average characteristics of the compliers. Most importantly, I use subject-level academic records of students to construct two broad field-specific skills and investigate a potential selection on these field-specific skills.[5]

The estimates from the complier analysis are consistent with the findings from the reduced form analysis. The compliers have significantly lower scores on the pre-college entrance exam compared to those who would always choose the STEM track, the always-takers. Most importantly, the result shows substantial sorting on field-specific skills. In particular, the reform led to a positive sorting on field-specific skills. The compliers are better in skills valued more in STEM fields (henceforth, Science skills) relative to those who chose to stay in the Humanities, the never-takers. On the other hand, the compliers are worse in skills considered useful for success in the Humanities fields (henceforth, Humanities skills) than the never-takers. Finally, although the compliers are better in Science skills relative to the never-takers, they are considerably poorer in Science and Humanities skills than the always-takers. These findings are consistent with the predictions of self-selection models where agents maximize their college admission probability and field-specific skills are positively correlated (Willis and Rosen, 1979; Rosen, 1978; Roy, 1951).

The selection on field-specific skills described above has implications for the post-reform average quality of students in the two academic tracks. Specifically, the positive sorting on field-specific skills described above implies that the STEM track experiences a significant decrease in average peer quality in both Science and Humanities skills. On the other hand, the result predicts the average Science skills to decrease in the Humanities track, while the opposite is expected for the Humanities skills. To test these predictions, I examine the overall and field-specific peer qualities in the two academic tracks. Consistent with the previous findings, the overall peer quality falls in both tracks after the reform. More importantly, I find that the average Science skill falls considerably in both tracks (0.045 SD points or 12.5% and 0.187 SD points or 55% in the Humanities and STEM tracks, respectively). On the other hand, while the average Humanities skill decreased in the STEM track (0.093 SD points, 7%), the Humanities track experienced a substantial increase in Humanities skills post-reform (0.025 SD points or 19.5%). In general, the result shows the selection on field-specific skills resulted in a significant change in the overall and field-specific peer quality in the two academic tracks. Most importantly, the change in peer quality is consistent with a prediction of Roy (1951) model where skills are positively correlated, and the most valued field becomes more attractive due to a favorable change in the outcome the agents are maximizing.

Overall, this study highlights two key findings. The result implies that college admission concerns play a significant role in students' college field choices. The study also documents that this relationship is primarily driven by the field choices of marginal students (students near the admission cutoff point), underscoring the role of admission concerns. However, students do not naively sort into less selective college fields. In particular, I find substantial

[5] Our approach closely follows the approach suggested by Almond and Doyle (2011) based on Abadie (2003) and Angrist and Imbens (1995)

sorting on field-specific skills, which implies that students take their field-specific skill advantage into account in their academic track choices. The latter also implies that students understand their relative skill advantage in different college fields and the implication of their choices for different outcomes (e.g., college admission probability). This finding is in contrast with the findings in the existing studies that students are often less well-informed and make systematic mistakes in their educational choices (Shorrer and Sóvágó, 2018; Hastings et al., 2016; Huntington-Klein, 2015). On the other hand, the selection on field-specific skills we documented in this study is consistent with the predictions of the models of self-selection in educational choices (Willis and Rosen, 1979; Rosen, 1978).

This study contributes to at least three areas of literature. First, this study is related to the literature on the effect of uncertainty on students' human capital investment decisions (Bordon and Fu, 2015; Stange, 2012; Altonji, 1993). These studies find that college outcome uncertainty (e.g., college completion and field-specific match uncertainty) substantially influences students' college enrollment and dropout decisions. The current study investigates a common yet not well-studied uncertainty and how it affects students' college field choices. This study also contributes to the literature on strategic reporting of preferences to 'game' a centralized admission system (Chen and Kesten, 2017; Abdulkadiroğlu et al., 2011). These studies show that students trade off an opportunity to attend an elite school for guaranteed admission into a lower-quality school (Wang et al., 2021; Chen and Kesten, 2019). This study investigates whether a similar trade-off exists in the context of college field choice. Finally, this study contributes to the literature on college admission competition and signaling investment and college application behavior of students (Bound et al., 2009; Robinson and Monks, 2005). These studies report that students respond to an increase in college admission competition by increasing diverse signaling investments (e.g., taking high school science and mathematics courses and standardized tests). Others document strategic behavior in students' college applications, including an increase in the number of applications sent per student and the diversity of colleges to which students apply. This study documents similar strategic behavior in field choice and highlights the implication for peer quality in different college fields.

The rest of the paper is organized as follows. Section 2 describes the institutional setting. In Section 3, I describe the data. Section 4 presents the empirical strategy. Specifically, Section 4.1 discusses the reduced form estimation. In Section 4.2, I present a framework for complier characteristics analysis. In Section 5, I present the results of the study. Section 6 concludes and discusses some implications.

2 Institutional Details

2.1 The Ethiopian Pre-college Program

This section describes the pre-college program and a lower-level general high school that feeds the program. The high school system in Ethiopia is a two-layered program, constituting the later two levels of an 8-2-2 national education curriculum implemented by the Ethiopian Education and Training Policy in 1994 (Joshi and Verspoor, 2012). A diagram summarizing the high school structure is provided in Figure A.1. The first level of the system, known as the General High School Program, comprises Grade 9 (G9) and Grade 10 (G10). Students are admitted to the General High School after completing eight years of primary and middle school curriculum and achieving the required admission score on a regional Middle School Leaving Certificate exam. In this program, students study a general curriculum that includes English, Mathematics, and other academic subjects in physical and social sciences and humanities. At the end of the program, students are required to take a standardized pre-college entrance examination (PEE). The exam is standardized and arguably comparable across cohorts.[6] The exam score is reported in one of 5 letter grade scales for each subject: A, B, C, D, and F. These letter grades are converted to Grade Point Average on a 4 point scale. Students scoring above an admission cutoff point will be admitted to a pre-college program, the second level of the high school structure. Those who fail to score the required threshold for admission to the pre-college program are allowed to re-take the exam one year later during the next exam cycle.

The second level of the high school system, the pre-college program, comprises Grade 11 (G11) and Grade 12 (G12). This program is designed to prepare students for college-level education and trains students in a specialized curriculum traditionally taught in the first year of college (Joshi and Verspoor, 2012). At the beginning of the pre-college program, students choose one of the two academic tracks: the Science, Technology, Engineering, and Mathematics track (henceforth, STEM) or the Social Sciences and Humanities track (henceforth, Humanities). The admission cutoff for the pre-college is not track-specific, i.e., students scoring above the common admission cutoff point can choose to specialize in either academic track. While some courses are common to both academic tracks, other courses taught in the program are field-specific. In particular, English, Mathematics, and Civic and Ethical Education are taught to students in both tracks.[7] The field-specific courses in STEM include Biology, Chemistry, Physics, and Technical Drawing. On the other hand, students in the Humanities track study Economics, History, Geography, and Business Education.

At the end of the pre-college program, students take a standardized Ethiopian College Entrance Examination (CEE). The CEE is a set of six subject-level exams and one local Scholastic Aptitude Test (SAT), each of which is graded and reported on 100 points scaled score. While the STEM track students write Mathematics, English, Biology, Chemistry, Physics, Civics and Ethical Education exams, those in the Humanities track take subject-level exams in Mathematics, English, Economics, Geography, History, and Civic and Ethical Education. The CEE is a high-stakes exam because college admission solely depends on the student's score on it. Students scoring above the track-specific admission cutoff are admitted to college. The admission cutoff for each track is centrally determined. Specifically, the cutoff

[6] Each year the National Educational Assessment and Examination Agency (NEAEA) randomly selects a set of questions for each subject from what is referred to as an *Exam Bank* to administer it in June or July.

[7] While 7 of 9 chapters covered in Grade 11 Mathematics curriculum are identical across both tracks, the other two chapters are specific to each academic track. Similarly, only two chapters in Grade 12 Mathematics curriculum are specific to each academic track.

is determined by ranking students in each track based on their admission exam score and admitting students starting from the top until all the seats allocated to the academic track are filled.

The college admission system in Ethiopia is highly centralized and score based. The Ministry of Education (MOE) and the National Educational Assessment and Examination Agency (NEAEA), serving as a Central Clearing House (CCH), admit students scoring above the college admission cutoff point and assign them a college-field pair in public universities across the country. Those scoring below the cutoff point have three outside options. First, students can continue their college studies in a small private higher education market. However, private universities are considered low-quality schools, with the admission cutoff points for private universities significantly lower than those for public universities. Furthermore, public universities are tuition-free and cover almost all living expenses (including food and boarding) of all admitted students, while private universities charge exorbitant tuition. Second, students can retake the exam and apply for college admission in the next academic year. Third, students can directly join the labor market. Furthermore, the admission system is field-specific. Students in the pre-college STEM track will be admitted to college STEM fields. Similarly, students choosing the Humanities track at the pre-college are admitted to college fields in social sciences and humanities. College studies take 3-5 years depending the college field the student chooses to study.

The Ethiopian formal labor market is the main destination for those who graduate from college. So, I next briefly describe the Ethiopian formal labor market, focusing on key features relevant to students' college field choice. First, the public sector (civil service and parastatals) is a dominant player in the formal labor market (World Bank, 2007). The sector employs two-thirds of workers in the formal labor market. In the skilled segment of the market, the sector employs more than 68 percent of those with college degrees. Given that public sector pay scales are fixed and widely known for major professions, students are likely informed about the earning differentials across professions (Mussa, 2005). Second, the labor market outcome for college graduates is substantially better than those for high school graduates. In 2005, for example, the unemployment rate among college graduates was less than 5 percent, while the figure for those who never completed any college education was more than 14 percent (Broussard and Tekleselassie, 2012). Descriptive evidence also suggests that those with a college degree earn substantially large unconditional wage premiums relative to high school graduates (Salmi et al., 2017; Seid et al., 2015).[8] This suggests that college degrees carry significant labor market value both in terms of job security and earnings. Further, studies also show that, in the formal sector, there are large earning variations across different professions, industries, and the type of employer (World Bank, 2007; Mussa, 2005).

Overall, the institutional settings described above have implications for students' college field choices. In particular, the field-specific and centralized nature of the college admission sys-

[8] International Labour Organization (2016) estimate also suggests that, in contrast to the trends in many low and lower middle-income economies, college graduates are more likely to be employed compared to those without a college degree.

tem suggest that students have a strong incentive to trade off their preferred college field to increase their probability of college admission in the central system. Furthermore, although there are significant earning differences across different college fields, the labor market is also characterized by large college premiums in terms of wage and employment security. This suggests that, in monetary terms, for the marginal student, concerns over college admission should trump those related to field choice.

2.2 The College Admission Policy Reform

Until mid-2008, the Ministry of Education of Ethiopia had an unstated policy of allocating approximately half of the total college seats available in public universities to the students in each of the two pre-college academic tracks.[9] As part of a five-year Education Sector Development Plan III (ESDP-III) (2006-2010), the Ethiopian government claims to have made a strategic policy decision to increase investment in Science, Technology and Engineering and Mathematics (STEM) education at higher learning levels (MOE, 2005). One key component of this strategic policy decision is expanding access to STEM fields in public colleges.

Accordingly, in August 2008, the Ministry of Education introduced a college admission policy reform that significantly changed the proportion of college seats allocated to students in the pre-college STEM and Humanities academic tracks. The reform, widely known as the 70-30 Undergraduate Professional Degree Mix, required all public universities and colleges in the country to allocate 70 percent of their total available seats (and resources) to enrollment in Science, Technology, Engineering, and Mathematics programs. The remaining 30 percent of the public university seats were allocated to fields in Social Sciences, Humanities, and Business and Economics. Figure 1 shows the trends in the share of college seats allocated to the two academic tracks for pre-college graduating cohorts 2005-2018. The figure shows a significant increase in the share of college seats allocated to STEM fields starting from cohort 2009 (C2009), the first cohort affected by the reform, and reaching the mandated 70 percent the following year in 2010.[10] Although the policy was originally planned to take effect starting from C2009, the mandate was never fully implemented in 2009, with STEM students accounting for only 60 percent of the total college seats available in public universities. The data suggest that this is because there were not enough students to meet the quota required under the new policy even after admitting nearly 100 percent of students in the STEM track in C2009. The share of college seats allocated to the STEM track remained near the mandated 70 percent for the next several years until the Ministry of Education abandoned the policy in 2018 (MOE, 2018).

Given that students make their academic track choice at the beginning of the pre-college

[9]This information is from a discussion the author had with education policy experts at the Ministry of Education of Ethiopia. In addition, college admission data from the years before the reform confirms this evidence (see Figure 1 below).

[10]The effect of the policy is also clear from the trend in the college admission cutoff points for the two pre-college admission cutoff points. Figure A.2 shows that the admission cutoff for college STEM fields for C2009 is significantly lower than the cutoff for college fields in social sciences and humanities.

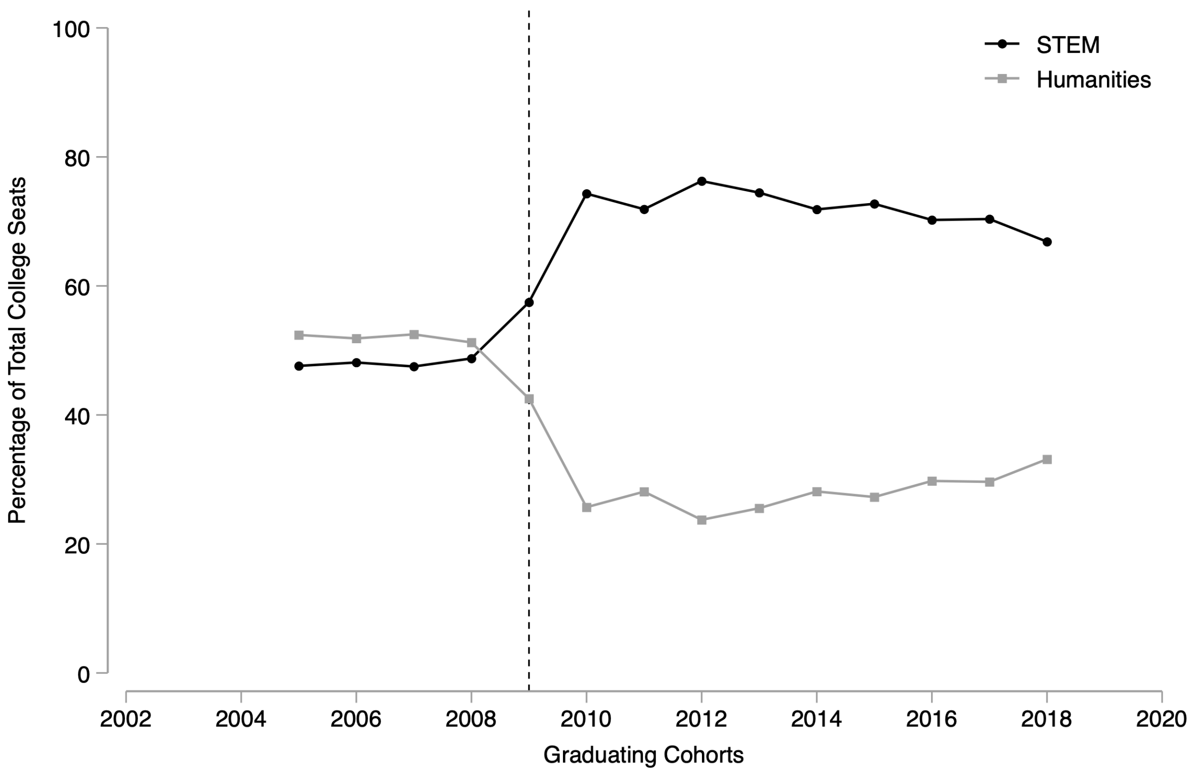

Figure 1: Share of College Seats Allocated to Pre-college Academic Tracks

Note: This graph shows the share of college seats allocated to pre-college STEM and Humanities tracks. Cohorts are defined based on the year of graduation of the cohort from the pre-college program. The dotted vertical line shows the first cohort treated by the reform.

program, two years before they sit for the college admission exam, the reform restricted field choice and investment decisions of cohorts near the announcement date of the reform in different ways and intensities. Figure 2 shows how different cohorts were affected by the reform. Figure A.3 shows a detailed timeline of events for cohorts near the announcement date of the reform. The reform was announced in August 2008 and took effect in cohorts graduating from pre-college program in 2009. As a result, C2009 and all later cohorts were subject to the new college seat allocation rule and are considered treated by the policy reform. However, C2009 made their pre-college academic track choice in September 2007, nearly one full year before the announcement of the reform. On the other hand, C2010 and later cohorts made their track choice after the announcement of the reform. As a result, C2010 and later cohorts had the opportunity to factor in the potential effects of the reform into their academic track choice decisions.

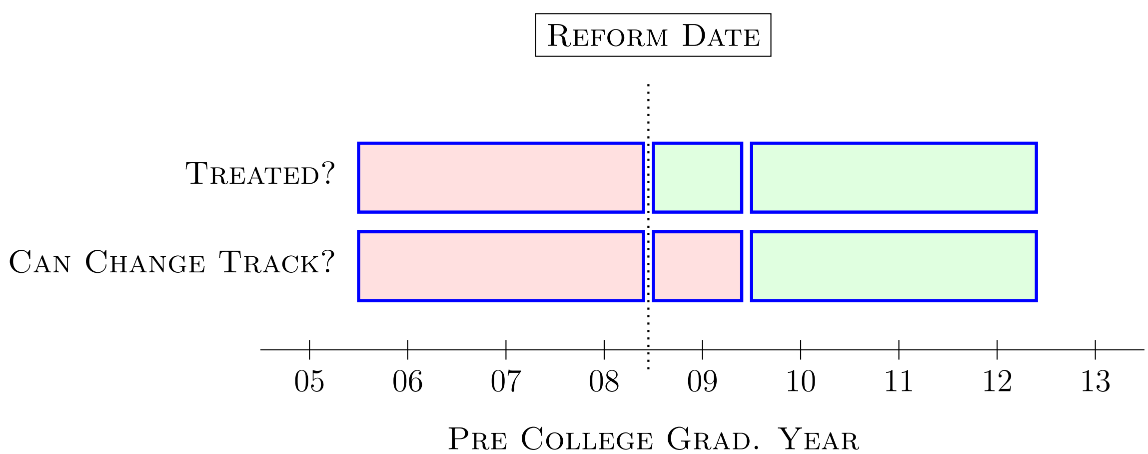

Figure 2: Reform and Cohorts – Illustrative Timeline

Note – This diagram illustrates treatment statuses of different cohorts. The reform is announced in August 2008. Since the reform takes effect starting from C2009, C2009-C2018 are considered treated, i.e. subject to the new seat allocation rule. However, C2005-C2009 made their pre-college academic track choice before the announcement of reform. Therefore, only C2010 and later cohorts had the opportunity to incorporate the potential effect of the new policy in to their track choice decisions. In sum, although the reform starts to take effect on C2009, only C2010 and later can change their track choice in response to the reform. Green represents a 'YES', Red represent a 'NO'.

The high school structure and the reform described above provide a useful setting to study the effect of admission concerns on the field choice behavior of students. First, the reform is a result of a forward-looking strategic policy decision to promote economic growth by changing the supply of STEM graduates in the local labor market (MOE, 2008). This implies that the reform is not a response to a contemporaneous or projected trend in students' field choice behavior or their academic outcomes. Furthermore, the reform is not a response to an anticipated increase in demand for STEM graduates in the local labor market. Second, the college admission policy reform and the national economic development strategy included no credible labor market policy change that students expect to alter the labor market desirability of some college fields relative to others.[11] Moreover, while the number of total college

[11]The policy document claims that the increase in STEM graduates in the local labor market promotes

seats in public universities has substantially increased over the study period, the ratio of college seats to the student population in the general high school and the pre-college program remained stable (see Figure A.4). Third, given that the policy was not pre-announced and the public was unaware that the policy was in the pipeline, one can clearly define treated and non-treated cohorts. The latter also suggests that cohort manipulation to take advantage of the reform and anticipation effects in field choice behavior are unlikely to be a concern.

3 Data

This study uses two sets of academic records corresponding to the two Ethiopian high school programs described above. The first data set comes from the pre-college entrance exam records of the universe of students enrolled in the Ethiopian General High School program between 2003 - 2016. The pre-college entrance exam is a set of subject-level exams including Mathematics, English, Civics and Ethical Education, Biology, Chemistry, Physics, Geography, History, *Amaharic* Language and one other language corresponding to the official language of a regional state in which the student attended school. The data provide detailed subject-level letter grades on the exam. The letter grades are either A, B, C, D or F with assigned numerical values of 4, 3, 2, 1, or 0, respectively, which are used to calculate the Grade Point Average (GPA) of the student. The data also contains some demographic information, including the student's age, gender, and disability status. We also observe some basic information about the school, including school region, school zone, whether the school is private or public and whether the school is a specialized school or not. The data contains information on whether the student is re-taking the exam for the second time.

The second data set contains academic records of over 2 million students who attended the Ethiopian pre-college program between 2005 - 2018 and subsequently took the college entrance exam. The exam consists of seven subject-level exams, six of which are taught in the pre-college program. The seventh exam is a locally prepared standardized Scholastic Aptitude Test (SAT). While English, Mathematics, Civic and Ethical Education, and local SAT exams are identical across the two academic tracks, the other three subject-level exams are specific to each academic track. Specifically, students in the STEM track take subject-level exams in Biology, Chemistry, and Physics, and those in the Humanities track write subject-level exams in Economics, History, and Geography. These subject-level exams are graded on a 100 points scaled score and reported separately for each subject. A student's total exam score is calculated as an unweighted sum of all the subject-level scores. The college admission cutoff point for each academic track is determined by the total college seats available to the academic track, admitting students starting from top scorers until all the seats are filled. The data also includes information on the academic track chosen by the student, demographic variables such as student gender, student age, and physical disability, and school information, including school region, school zone, and whether the school is private or public. We also have data on whether the student is re-testing or not.

growth by increasing the number of 'knowledge workers', job creators and entrepreneurs (MOE, 2008)

We link the two data sets using student identification information. We restrict the sample to students whose identification in both data sets uniquely matches. To keep the analysis in a comparable sample, we restrict the analysis sample to regional states with similar pre-college and college admission requirements. Specifically, the analysis sample includes students from four major regional states (Tigray, Amhara, Oromia, and Southern Nations and Nationalities) and two city administrations (Addis Ababa and Dire Dawa). The final sample accounts for more than 90 percent of the student population enrolled in the two high school systems during the period under study. Since admission standards for disabled students differ from the rest of the students, we exclude these students from the analysis. Further, we exclude students in special schools (e.g. schools in prison facilities, non-public and non-private schools run by the non-governmental organizations, schools specializing in STEM fields), and students whose scores in one or more of subject level exams are missing[12]. The linked final sample includes more than 1.6 million students who took the Ethiopian college admission exam between 2005 and 2018 and whose complete records in the general high school and pre-college programs are available. The sources for our data sets are the Ethiopian Ministry of Education (MOE) and the National Educational Assessment and Examinations Agency (NEAEA).

Table 1: Summary Statistic of Some Variables

	N	All	PRE–Reform	POST–Reform	$t = 2008$	$t = 2010$
Female	1,656,719	0.423	0.353	0.449	0.392	0.401
Age	1,321,558	18.974	18.778	19.032	18.833	18.969
Private School – GH	1,656,719	0.127	0.100	0.132	0.118	0.139
Private School – PP	1,656,719	0.092	0.074	0.096	0.084	0.099
Re-taking Exam – PEE	1,656,719	0.128	0.089	0.143	0.130	0.136
– GPA	1,656,719	2.585	2.446	2.591	2.489	2.476
– STEM GPA	1,656,719	2.501	2.424	2.536	2.477	2.434
– Humanities GPA	1,656,719	2.679	2.636	2.707	2.543	2.557
STEM Students						
– GPA	1,656,719	2.668	2.613	2.676	2.676	2.475
– STEM GPA	1,656,719	2.607	2.540	2.616	2.708	2.328
– Humnities GPA	1,656,719	2.730	2.634	2.743	2.615	2.677

Note: This table presents summary statistics of some of the variables used in the analysis. The first column is summary of all observations used in the analysis. The third and fourth column compare the average characteristics cohorts before and after the reform. The average characteristics for 2008 and 2010 in the last two columns show the averages for cohorts immediately before and after the reform. The overall GPA is the average of all seven subject level letter grades on the pre-college entrance exam. STEM GPA is the average of grades on Mathematics, Biology, Chemistry and Physics. The Humanities GPA is calculated from student grades on Reading Comprehension, History, Geography and Civic and Ethical Education for STEM track students. The last three rows are grades for STEM track students.

[12]This usually happens if the student missed the exam for any reason or the student is dismissed from the exam room for violation of exam protocols.

The summary of linked data is presented in Table 1 below. The students in our final sample are 16-17 years old when they join the pre-college program. Despite a preferential admission policy, female students account for only 46 percent of the student population in the pre-college program. Public schools account for nearly 90 percent of the general high school (GH) and pre-college program (PP) student population. Close to 13 percent of students retake the pre-college entrance exam. The average student in the pre-college program scores 2.5 on 4 point scale on the pre-college entrance exam. On average post-reform cohorts score higher on the pre-college entrance exam relative to pre-reform cohorts. Focusing on student sorting, the STEM track, on average, attracts high-achieving students both before and after the reform. Figure A.5 in the appendix also shows that high-achieving students are more likely to choose STEM track both before and after the reform. A comparison of cohorts before and after the reform shows that the observable characteristics are arguably balanced. In particular, Table 1 suggests that cohorts immediately before and immediately after the reform are comparable in both demographic characteristics and academic preparation.

In addition to the main data sets, we use data on actual and imputed pre-college and college admission cutoff points. The cutoff points for entrance to the pre-college program were collected from the Ministry of Education (MOE) and the National Educational Assessment and Examination Agency (NEAEA) of Ethiopia. Similarly, the college admission cutoff points for cohorts 2009-2018 were collected from the same source and are actual cutoff points used to admit students to public universities and colleges. For cohorts 2006-2008, the college admission cutoff points are imputed by linking public universities' freshman enrollment data in Education Statistics Annual Abstract and the college admission exam records described above. Specifically, to obtain the approximate cutoff point, we compute the total number of first-year students enrolled in all public universities in each field (and hence, their academic track) for each cohort. Then we use this total enrollment number and college entrance exam records of the same cohort to guess the admission cutoff point for the cohort. Accordingly, the cutoff points data for these cohorts should only be interpreted as an approximation of actual cutoff points. I use these cutoff points data to determine students' pre-college and college admission outcomes.

4 Empirical Strategy

4.1 Estimation

The objective of this study is to estimate the causal effect of college admission selectivity on the field choice of students. The main challenge in estimating the effect of college admission selectivity on the field choice of students is the potential effect of confounding variables driving both the admission selectivity and the desirability of college fields. In this study, we leverage the college admission policy reform in Ethiopia that substantially changed the ratio of college seats in public universities allocated to the pre-college STEM and Humanities tracks from 50:50 to 70:30 in favor of STEM. Specifically, we estimate the following reduced form specification:

$$y_{it} = \alpha + \gamma \cdot POST_t + \mathrm{X}'\Gamma + \eta_s + \xi_{it}$$

where y_{it} is a binary variable taking 1 if student i in cohort t is in the pre-college STEM track, 0 otherwise; $POST_t$ is a binary variable taking 1 for post-reform cohorts and 0 otherwise; X is a set of controls including the type of school the student attended (private or public), student age, student gender and whether the student re-tested on the pre-college entrance exam. γ is the coefficient of interest. η_s is a school fixed effect. ξ_{it} is a random error.

Mechanically, a small change in admission selectivity of college fields is likely to substantially affect the college admission probability of marginal students compared to those of inframarginal students. As a result, the effect of college admission selectivity on the field choice decision of students is unlikely to be the same across the achievement distribution (Estevan et al., 2019; Bond et al., 2018).[13] In our setting, a small change in the admission cutoff in favor of the STEM track is likely to lead to a larger response among the marginal students, with the effect dying out as one moves further from the admission cutoff point on both sides (i.e., an inverse U-shape effect)[14]. In light of this hypothesis, we investigate whether the policy reform and its effect on the admission selectivity of the two academic tracks lead to a heterogeneous response in field choice of students by estimating the following modified specification:

$$\begin{aligned} y_{it} = \alpha + \theta \cdot POST_t + \sum_{k=1}^{9} \delta_k \cdot \mathbb{1}\{DEC_{it} = k\} \\ + \sum_{k=1}^{9} \gamma_k \cdot \mathbb{1}\{DEC_{it} = k\} \times POST_t + \mathrm{X}'\Gamma + \eta_s + \xi_{it} \end{aligned}$$

where y_{it} is a binary variable taking 1 if student i in cohort t is in the pre-college STEM track, 0 otherwise; $POST$ takes value 1 for post-reform cohorts or 0 otherwise, DEC_{it} is the achievement decile of the student on the pre-college entrance exam and the top decile is the base group; X is a set of controls including the type of school the student attended (private or public), student age, student gender and whether the student re-rested on the pre-college entrance exam. γ_k is the coefficient of interest. η_s is a school fixed effect. ξ_{it} is a random error.

Identification of the causal effect in the above specifications comes from cross-cohort comparison. One potential concern is whether the pre-reform cohorts are comparable to the

[13] Montmarquette et al. (2002) provides a simple theoretical exposition of a similar hypothesis where the trade-off between probability of admission to a college field and lifetime earning in a related occupation is starkly different across achievement profiles of students.

[14] The overall admission rate in the pre-college program in years leading up to the admission reform fluctuated between 70-80 percent. This implies that the second and third decile students are likely to be marginal in the pre-reform college admission regime.

post-reform cohorts. We argue that the cohorts are comparable. First, students are admitted to the pre-college program based on standardized criteria comparable across cohorts. Specifically, admission to the pre-college program is based on a standardized pre-college entrance exam (Joshi and Verspoor, 2012). In addition, a comparison of the demographic characteristics and academic records of cohorts before and after the reform suggests that the cohorts before and after the reform are comparable (see Table 1 in Section 3 and Figures A.6 and A.7 in the appendix). Finally, we provide estimates from different sample restrictions, limiting the estimation sample to cohorts immediately before and after the reform, and we show that the estimates are consistently stable.

In addition, the policy reform may lead to a higher pre-college enrollment among students who would not have attended the program absent the reform. In this case, our specification will likely overestimate the effect of college admission concerns on the college field choice of students. We test the plausibility of this differential pre-college program enrollment across cohorts by examining the presence of sharp change in the proportion of students who choose to attend the pre-college program among the eligible students. A sharp increase in this proportion among the first cohort joining the pre-college program after the announcement of the reform, cohort 2010, is a possible evidence of differential attendance of the program due to the admission policy reform. Figure A.9 in the appendix shows that there is no evidence of differential pre-college program attendance in the first cohort treated by the reform.

A related concern is that the reform may lead to a *cohort manipulation* by students in the cohorts near the announcement of the reform. In particular, students in the Humanities track in cohort 2009 have a strong incentive to drop out of the pre-college program and possibly re-join the program the following academic year. We examine the plausibility of this concern by studying the proportion of students out of their general high school cohorts.[15] Any sharp change in the proportion of students out of their cohort in C2010 is a possible evidence of cohort manipulation. Figure A.8 shows that there is no evidence of a sharp change in the proportion of students out of their cohort, in particular, immediately after the reform.

Finally, as a robustness check, we provide a local Regression Discontinuity (RD) estimate that relies on the within-cohort comparison. In particular, using students who took the pre-college entrance exam in 2007 (cohort 2009), I compare the field choices of students just below and just above the pre-college admission cutoff point. While both of these students attended the general high school in the same cohort, those below the admission cutoff point were forced to wait one more year to re-take the exam and, as a result, made their pre-college track choice after the announcement of the reform. We use this random assignment to treatment and control by the admission threshold to construct an RD design. Details of this robustness check will be provided in Section 5.3.

[15] To do this, I first fix cohorts based on the year students take the pre-college entrance exam. A student is considered *out of her cohort* if she took the college admission exam more than two years after she took the pre-college entrance exam

4.2 Description of Compliers

Individuals induced by the college admission policy reform to choose the STEM track, the *compliers*, are unlikely to be randomly drawn from the student population who would have chosen the Humanities track absent the reform. Therefore, understanding the characteristics of the compliers can be useful for many purposes. In particular, understanding the sorting pattern that results from the admission policy reform and the characteristics of the compliers can be informative of any change in the composition of students in both tracks and its implication for average peer quality and learning outcomes (Bianchi, 2020). While the *always takers* (AT), students who choose the STEM track regardless of the reform, and the *never takers* (NT), students who choose the Humanities track regardless of the reform, can be identified under certain assumptions, individual *compliers* are not identifiable. However, we can compute their share among the analysis sample as well as the distribution of their characteristics (Abadie, 2003; Angrist and Imbens, 1995).[16] In this section, we adopt the approach suggested by Almond and Doyle (2011) and estimate the average characteristics of those induced by the policy reform to study STEM in the Ethiopian pre-college program.

To do this, define a binary variable R such that

$$R = \begin{cases} 0, & \textit{pre-reform cohort} \\ 1, & \textit{post-reform cohort} \end{cases}$$

Further, define another binary variable, S, an indicator of whether the student choose to study STEM or Humanities,

$$S = \begin{cases} 0, & \textit{chooses STEM track} \\ 1, & \textit{chooses Humanities track} \end{cases}$$

Finally, define S_R as the value S takes if R is either 0 or 1. For instance, $E(X|S_1 = 1)$ is the average characteristics of students who choose to study STEM track in the post-reform cohorts.

In this setting the *compliers* are defined such that $S_0 = 0$ and $S_1 = 1$. To consistently estimate the average observable characteristics of the *compliers*, we assume the following two conditions hold: independence and monotonicity. Independence implies that S_0 and S_1 are jointly independent of R. In other words, this assumption means R is 'as good as randomly assigned' (Abadie, 2003). In the context being studied, this excludes the possibility that the policy reform is a response to the contemporaneous or projected trend in the field choice behavior of students. This assumption is also violated if a significant proportion of students are able to successfully manipulate their year of graduation to increase their college admission probability. Although this condition is not testable, given that the reform is an exogenous policy change, this condition is unlikely to be violated. Moreover, studying the

[16] In the literature, this approach is used to back out the average characteristics of individuals for which Local Average Treatment Effect (LATE) is identified, those induced by an exogenous change in the *instrument* to change their treatment status. See for example, Almond and Doyle (2011) and Daysal et al. (2015).

proportion of students out-of-cohort, we find no evidence of cohort manipulation in the pre-college enrollment and academic track choice (see Figure A.8 in the appendix). Monotonicity requires that $S_1 - S_0 \geq 0, \forall i$. This implies that a student who would choose the STEM track absent the reform would also choose the STEM track under the new admission policy. In simple terms, this assumption implies that there are no defiers. Since we only observe S_1 or S_0, this assumption is not testable. However, monotonicity seems plausible given that the Humanities track is likely to be highly selective post-reform.

Now consider the average characteristics of students choosing STEM track in the post-reform cohorts, i.e. $E(X|S_1 = 1)$. This group is comprised of the AT (always STEM) and those induced by the reform to choose STEM track (the *compliers*). In short:

$$E(X|S_1 = 1) = E(X|S_0 = 1, S_1 = 1) \cdot P(S_0 = 1|S_1 = 1) + E(X|S_0 = 0, S_1 = 1) \cdot P(S_0 = 0|S_1 = 1)$$

Monotonicity condition implies that the AT can be described by the characteristics of students who studied STEM track ($S = 1$) in the cohorts before the reform ($R = 0$). That is $E(X|S_0 = 1, S_1 = 1) = E(X|S_0 = 1)$. Therefore, the above equation can be re-written as

$$E(X|S_1 = 1) = E(X|S_0 = 1) \cdot P(S_0 = 1|S_1 = 1) + E(X|S_0 = 0, S_1 = 1) \cdot P(S_0 = 0|S_1 = 1)$$

By independence, the population proportion of AT can be estimated by the the proportion of those in STEM before the reform.

$$P(S_0 = 1|S_1 = 1) = P(S_0 = 1) \equiv \pi_A$$

Similarly, the population proportion of NT can be estimated by the the proportion of those in Humanities after the reform.

$$P(S_1 = 0|S_0 = 0) = P(S_1 = 0) \equiv \pi_N$$

Independence of R implies that the proportion of AT is $\pi_A = P(S_0 = 1)$ and the proportion of NT is $\pi_N = P(S_1 = 0)$. Then, since monotonicity excludes the existence of defiers (proportion of *defiers*, π_D is zero), the proportion of the population who are *compliers* is given by $\pi_C = 1 - \pi_A - \pi_N$. Also, note that the fraction of students who studied STEM in the post reform cohorts is given by $P(S_1 = 1) = \pi_A + \pi_C$.

Finally, consider those in the STEM track before the policy reform,

$$P(S_0 = 1) = P(S_0 = 1|S_1 = 1) \cdot P(S_1 = 1) + P(S_0 = 1|S_1 = 0) \cdot P(S_1 = 0)$$

The second part on the right hand side represents the *defiers*. By monotonicty this part is zero. Therefore,

$$P(S_0 = 1|S_1 = 1) = \frac{P(S_0 = 1)}{P(S_1 = 1)}$$

Note that $P(S_0 = 1)$ can be estimated as the sample proportion of those in STEM before the reform, π_A. Similarly, $P(S_1 = 1)$ can be estimated as the sample proportion of those in STEM post reform, $\pi_A + \pi_C$. Then,

$$P(S_0 = 1|S_1 = 1) = \frac{\pi_A}{\pi_A + \pi_C}$$

.

Since, $P(S_0 = 0|S_1 = 1) = 1 - P(S_0 = 1|S_1 = 1)$, we also have the following,

$$P(S_0 = 0|S_1 = 1) = \frac{\pi_C}{\pi_A + \pi_C}$$

Finally, the expected characteristics of the *compliers* can then be obtained by re-arranging the above equation.

$$E(X|S_0 = 0, S_1 = 1) = \frac{\pi_A + \pi_C}{\pi_C}\left[E(X|S = 1, R = 1) - \frac{\pi_A}{\pi_A + \pi_C}E(X|S = 1, R = 0)\right]$$

Since the two conditional averages can be estimated using sample means, we can back-out the average observable characteristics of the *compliers*. Specifically, the average characteristics of the *compliers* is estimated as a weighted difference between the average characteristics of STEM students in the post-reform cohorts and the average characteristics of STEM students in the pre-reform cohorts.

5 Results

In this section, we present the results. In Section 5.1, we show the effect of the admission policy reform on the college admission selectivity of the two pre-college academic tracks. Section 5.2 presents the estimate from the reduced form specification. In Section 5.3, we show that the estimate from the reduced form specification is robust. In Section 5.4, we present results from the complier analysis and discuss sorting on field-specific skills. Finally, in Section 5.5, we study how those induced by the policy reform to choose the pre-college STEM track fared in college admission.

5.1 Policy Reform and Admission Selectivity

In this section, we show how the admission policy reform affected the college admission selectivity of the two pre-college tracks.[17] To do this, we compare the admission rate at school level in the STEM and Humanities tracks before and after the reform. In short, we estimate the following simple specification:

$$r_{st} = \gamma_0 + \gamma_1 \cdot POST_t + \gamma_2 \cdot STEM + \gamma_3 \cdot POST_t \times STEM + \mu_s + \xi_{st}$$

[17] In this study, we use admission rate and admission selectivity interchangeably to refer to the percentage of those admitted to college from those who take the college admission exam. In the literature, the two terms could have different definitions. In particular, admission selectivity refers to the college admission probability of a standardized student (Bound et al., 2009).

where r_{st} is college admission rate for students in the pre-college program at school s and in cohort t. STEM is binary variable taking 1 for STEM track and 0 for Humanities track. $POST_t$ is binary variable taking 1 for post-reform cohorts. μ_s is school fixed effect. ξ_{st} is the error term.

The structure of the pre-college program which requires students to spend two years in the pre-college program before they apply for college admission, allows us to separately estimate the effect of the policy reform and students' choice responses. The reform was announced in August 2008 and took effect in the next academic year (see Section 2). Therefore, starting from cohort 2009, 70 percent of the college seat will be allocated to students in the STEM track. On the other hand, only C2010 and later cohorts can potentially change their field choice decision in response to the policy reform (see Figure 2). This implies that while cohort 2009 is treated by the reform and will be subject to the new college seat allocation rule, students in the cohort had already locked their track choice decision at the time of the announcement of the reform.

Using this structure, we first estimate the effect of the admission policy reform on college admission selectivity of the two academic tracks holding students' sorting fixed. To get this estimate, we compare C2009, the first cohort treated by the new mandate, to pre-reform cohorts (C2006-C2008). This comparison captures the effect of the reform on admission rates in the two tracks while effectively shutting down the effect of students' sorting across the tracks due to the reform. The estimates are presented in Table 2 below (Column 1). The estimate shows that admission rate in the STEM track increased by 14.2 percentage points relative to the admission rate in the Humanities track. This is substantially smaller than the expected mechanical increase in admission rate due to the 20 percentage point increase in college STEM seats. This muted increase in the STEM admission rate is likely related to the fact that the new policy was never fully implemented until 2010 (see Figure 1). Therefore, this estimate is likely to be lower bound.

Table 2: Policy Reform and Admission Selectivity

Dep: Admission Rate	(1) C2005-08 vs C2009 (Short Term Effect)	(2) C2009 vs C2010-18 (Student Responses)	(3) C2005-08 vs C2009-18 (Overall Effect)
POST	0.0600***	-0.0812***	-0.0284***
	(0.0111)	(0.00973)	(0.0100)
STEM	0.0189***	0.160***	0.0170***
	(0.00498)	(0.00687)	(0.00503)
$POST \times STEM$	0.142***	-0.156***	-0.00486
	(0.00821)	(0.00749)	(0.00559)
N	19,285	109,818	122,736
R^2	0.249	0.224	0.192

Note: The estimates are from: $r_{st} = \gamma_0 + \gamma_1 \cdot POST_t + \gamma_2 \cdot STEM + \gamma_3 \cdot POST_t \times STEM + \mu_s + \xi_{st}$, where r_{st} is college admission rate at school s and cohort t. STEM is binary variable taking 1 for STEM track. $POST_t$ is binary variable taking 1 for post-reform cohorts. μ_s is school fixed effect. ξ is the error term.Column 1 compares admission rates before and after the reform. Column 2 compares pre-reform cohorts to C2009, treated but locked cohort. Column 3 compares C2009 to other treated cohorts (2010-2018). *** p<0.01, ** p<0.05, * p<0.1

Given this large admission advantage in the STEM track due to the reform, we expect a significant increase in the proportion of students who choose the pre-college STEM track. To estimate the effect of potential sorting on the college admission selectivity in the two tracks, we compare the admission rate in C2009, the first cohort treated by the policy, to the admission rate in the later cohorts. Note that while C2010 and later cohorts made their track choice after the announcement of the reform, C2009 chose their academic track in 2007. However, the new seat allocation rule applies to C2009 and later cohorts. As a result, this comparison estimates the effect of sorting across academic tracks in response to the reform keeping the direct effect of the reform on admission selectivity fixed (keeping the proportion of the college seats in STEM fixed at the post-reform level) (See Figure 2. The estimate from this sample is presented in Column 2 in Table 2. The estimate shows that the college admission advantage in the STEM track fell by an almost similar magnitude as the increase in the STEM admission rate due to the policy reform. This suggests that student sorting eliminated the short-run college admission advantage in the STEM track due to the reform.

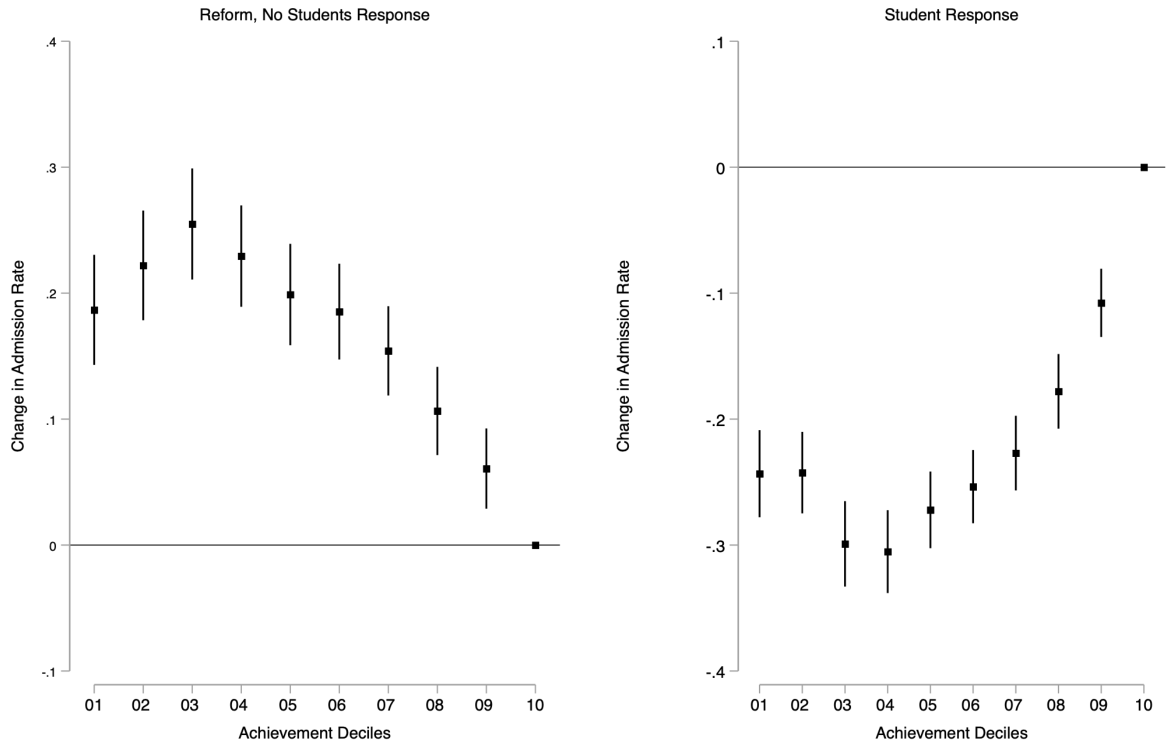

Figure 3: Reform, Student Responses and College Admission Rate - Heterogeneity

Note: These two plots show the heterogeneity in the effect of the reform (left) and student responses (right panel) on the admission rates in the two pre-college tracks. The left panel compares C2009 to pre-reform cohorts (C2006-C2008). The panel in the right compares admission rate in C2009 to the admission rate in C2010-C2018. Achievement deciles are computed from the student score on the pre-college entrance exam

Finally, to study the long-run effect of the reform and student sorting on the admission selectivity in the two academic tracks, we compare the admission rate for cohorts treated by the reform (C2009-2018) to the admission rate among pre-reform cohorts (Table 2 Column 3). The estimate from this sample captures the combined effect of the admission reform and the possible student sorting across tracks. Consequently, the estimate provides the long-run equilibrium effect of the new admission policy on the college admission selectivity in the two pre-college tracks. Not surprisingly, the estimate is statistically not different from zero, suggesting that the unconditional college admission advantage in the STEM track was quickly eliminated by student sorting across academic tracks.

The above estimates are the average effect of the reform and students' responses on the admission rate in the two pre-college tracks. However, a marginal change in admission cutoff is likely to have a heterogeneous effect on the admission probability of students at different achievement levels. Specifically, the change in admission probability is likely to be larger for marginal students compared to infra-marginal ones. We study this mechanical heterogeneity using students' scores on the pre-college entrance exam. Figure 3 (left panel) plots the estimates from comparison of C2009 and to the pre-reform cohorts.[18] This estimates correspond to the estimate in Table 2, Column 1. The estimates are intuitive. The increase in the STEM admission rate due to the reform is larger for low-achieving students. Specifically, the increase is the largest for marginal students. The right panel in Figure 3 provides estimates from comparison of C2009 to all later cohorts (this panel corresponds to the Column 2 in Table 2). The result from the latter points to a possible heterogeneity in student responses.

5.2 Students' Field Choice Response

In the last section, we noted that despite the permanent increase in the proportion of college seats in the STEM track, the college admission advantage in the track was short-lived. This suggests a possible sorting of students into the STEM track in the post-reform cohorts. In this section, we study the pre-college track choice responses of students to the policy reform. Table 3 presents estimates from a reduced form specification that compares the track choices of cohorts before and after the reform. The estimates are marginal effects from logistic regression. The first two columns present estimates using all cohorts (C2005 - C2018). The estimates suggest that students in the post-reform cohorts are 23 percentage points more likely to choose the pre-college STEM track relative to those in the pre-reform cohorts. The estimates are robust to the inclusion of controls and school fixed effect. This increase in the proportion of students choosing the STEM track after the reform is comparable in magnitude to the increase in the proportion of college seats allocated to the college STEM fields.

One potential concern with this reduced form specification is that as we move further from the announcement date of the reform, other secular trends might affect the track choice behavior of students. One possible confounding factor is the labor market effect of the policy reform itself. The policy reform is likely to dramatically increase the supply of STEM graduates in the local labor market, possibly leading to a fall in returns to STEM skills and a significant increase in unemployment among STEM graduates. To address this potential concern, we estimate the same specification sequentially restricting the analysis sample to cohorts closer to the reform announcement date. Columns 3 and 4 in Table 3 are estimated using only two cohorts before and two cohorts after the reform. The last two columns are estimated using just one cohort before and one cohort after the reform. The estimates are consistently similar to those obtained from the full analysis sample. This sharp and consistent estimates suggest that the increase in the proportion of students choosing STEM track is unlikely to be driven by a confounding variables.

The above estimates provide an average response to the change in admission selectivity in the two academic tracks. However, the marginal students have strong incentive to trade-off compared to infra-marginal ones. To test for heterogeneity in response across achievement distribution, we estimate the reduced form specification with an interaction term between the post-reform binary variable and the achievement decile of the student on the pre-college

[18] The estimates are the coefficient of interaction between $POST_t \times STEM$ in the above equation and achievement decile of students.

Table 3: Policy Reform and Student Responses

	All Cohorts		C2007-C2011		C2008-C2010	
Dep: Binary STEM	(1)	(2)	(3)	(4)	(5)	(6)
POST	0.230***	0.245***	0.245***	0.252***	0.235***	0.243***
	(0.00115)	(0.00138)	(0.00155)	(0.00207)	(0.00237)	(0.00321)
Dep. Mean	0.465	0 .465	0.467	0.467	0.467	0.467
N	1,656,719	1,639,746	389,513	388,295	166,717	166,141
R2	0.039	0.077	0.065	0.085	0.0579	0.0743
Controls	×	×	×	×	×	×
School FE		×		×		×

NOTE: These estimates are from a main model comparing the academic track choices of pre and post reform cohorts. Controls include age and gender of the student, whether the student re-tested on pre-college exams and whether the student went to private school at general high-school and also at pre-college program. Since the reform was not fully implemented in 2009 and there is significant break from previous cohorts in terms of pre-college program attendance, C2009 is not included in the estimation. The first two columns are estimates from all cohorts. The next two pairs of columns are estimated by restricting the analysis sample to cohorts closer to the reform. *** p<0.01, ** p<0.05, * p<0.1

entrance exam. The coefficient from this interaction term is plotted in Figure 4 below. The left panel is estimated using the entire analysis sample, and the right panel is estimated using a restricted sample: two cohorts before and two cohorts after the reform. The estimates suggest that there is indeed considerable heterogeneity in the responses. In particular, the estimates show that the response is the largest among the student population most likely to be marginal in the pre-reform admission regime compared to the infra-marginal ones.

Previous studies find similar heterogeneity in college and field choice analysis. Bond et al. (2018) study whether college applicants update portfolio of colleges to which they apply upon receiving unanticipated shock generated by a release of SAT scores. The study finds large heterogeneity in the response, with high-achieving students responding more strongly compared to the low-achieving ones. In particular, the study finds that the high-achieving applicants choose a portfolio of colleges with higher (lower) selectivity upon receiving an unanticipated increase (a decrease) in SAT scores than the low-achieving applicants. Estevan et al. (2019) find that higher-ability public high school students are more likely to apply to more selective programs in response to a preferential admission policy that gives bonus points to public high school students compared to the low-achieving students.[19] While this heterogeneous response is not surprising, it has an implication for the peer quality in different college fields. We study the latter issue in detail in Section 5.4.

In summary, the reduced form estimates above show that students are substantially more likely to choose the STEM track post-reform. Given that the reform is unlikely to change students' perception about her ability or performance in different academic tracks, this es-

[19]Note that high-achieving students are more likely to be closer to the admission cutoff for admission to prestigious college fields compared to low-achieving students.

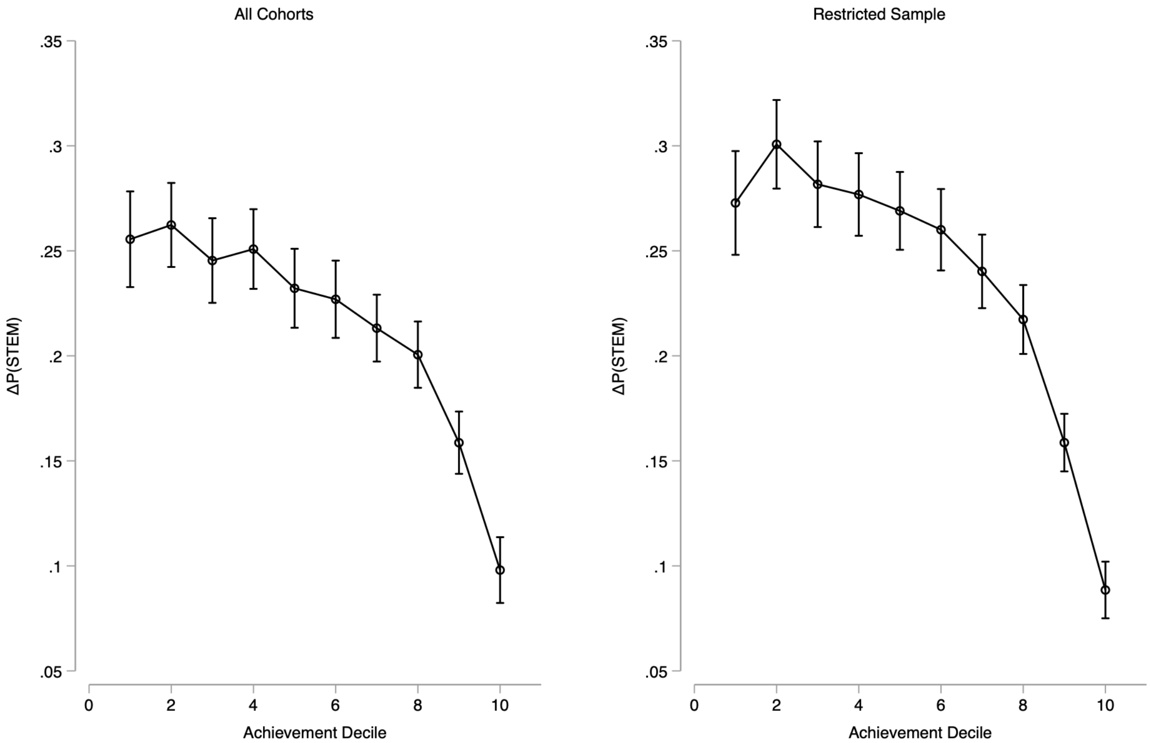

Figure 4: Admission Concern and Heterogenity in Sorting Across Tracks

Note: These two plots show the change in school level college admission rates due to the college admission reform for students with different achievement profiles. The left panel presents the change in admission rate between cohort 2009 and cohorts 2006, 2007 and 2008. The panel in the right presents the change in admission rate between cohorts 2010, 2011 and 2012 on one hand and cohort 2009 on the other.

timates imply that college admission concerns drive the sharp increase in the probability of choosing the STEM track. Overall, this finding implies that college admission concerns play an important role in students' college field choice in a field-specific college admission system. In particular, the heterogeneous response across the achievement levels suggests that college admission selectivity plays a significant role in the field choice behavior of marginal students. These results parallel the previous findings in the literature linking uncertainty about educational outcomes to human capital investment decisions of students (Bond et al., 2018; Bordon and Fu, 2015; Altonji, 1993).

5.3 Robustness Check: Regression Discontinuity Design

The main causal estimate in this section comes from cross-cohort comparisons. While the estimates from this specification are sharp and descriptive evidence suggests that cohorts before and after the reform are comparable, one might still be concerned about the reliability of estimates from the cross-cohort comparison. To address this concern, we provide a local Regression Discontinuity (RD) estimate that relies on a within-cohort comparison. As discussed in Section 2, a significant number of students who fail to score above the pre-college admission cutoff point choose to re-take the exam during the next exam cycle.[20] Conditional on scoring above the admission cutoff after re-testing, these students are allowed to attend the pre-college program with a cohort one year behind them. Therefore, among the cohort writing their pre-college entrance exam in 2007, those scoring above the admission cutoff point made their pre-college track choice in September 2007, one year before the announcement of the reform. On the other hand, students scoring below the cutoff point made their track choice in September 2008, one month after the announcement of the reform. We exploit this institutional detail and provide a local estimate comparing the field choices of students near the pre-college admission cutoff point in a cohort graduating from the general high school in 2007.[21] In short, using students' scores (Grade Point Averages) on the pre-college entrance exams as a running variable, we estimate the following specification:[22]

$$y_{i,2009} = \alpha + \gamma \cdot \mathbb{1}\{SCORE_{i,2009} < \bar{c}\} + f(SCORE_{i,2009}) + \mathrm{X}'\Gamma + \xi_{i,2009} \quad (1)$$

where $y_{i,2009}$ is a binary variable taking 1 if student i in cohort 2009 is in the pre-college STEM track, 0 otherwise; $SCORE$ is student's score on pre-college entrance exam on the first try, $\bar{c}$ is the pre-college admission cutoff point for cohort 2009; X is a set of controls including school level characteristics and student-specific characteristics such as age and gender of the student; $f(\cdot)$ is a flexible polynomial of student score on pre-college entrance exam; $\xi_{i,2009}$ is random error.

The advantage of the RD estimate above is that students near the admission threshold are likely comparable, directly addressing concerns related to the cross-cohort comparison above. In addition, since this RD estimate comes from a sample of students near the admission cutoff, the estimate is local to the student population of interest, i.e., students with a strong incentive to trade-off. On the other hand, it is plausible that there is a selection into retaking the exam. Specifically, those who choose to re-test are not a random draw from the student population who fail the exam on the first try. Moreover, students who score above the admission cutoff after re-taking are unlikely to be a random sample of those who re-test on the exam. We use C2008 and C2010, the control cohorts, to investigate any difference

[20] Students enrolled in the pre-college program after re-taking the pre-college entrance exam accounted for about 12.8 percent of the analysis sample. See Table 1.

[21] To be consistent with the definition of cohorts used in the previous sections, we use the cohort definition based on the pre-college graduation year and refer to students graduating from general high school in 2007 as C2009. Also, note that we use the cutoff point and Grade Point Average in the first time the cohort took the exam.

[22] The identification assumption is that students near the admission cutoff point are similar in every aspect other than their pre-college admission status. This assumption is violated when students can successfully manipulate their GPA to cross the cutoff, introducing a systematic difference between those below and above the admission cutoff. However, since exams are machine-graded and a federal agency manages all the academic records, it is unlikely that students can either manipulate their GPA or their pre-college admission status. Figure A.11 supports this claim.

in field choices due to selection into re-taking the exam and due to crossing the threshold conditional on re-taking the exam. Figure A.10 in the appendix presents a simple plot of the data.[23] We find no evidence of score manipulation around the cutoff (See Figure A.11). We also find that observable characteristics are balanced around the admission cutoff point (See Figure A.12).

The result from this exercise is presented in Figure 5. The estimates from RD design confirm our estimates from the main specification. We find very small but significant discontinuity in the proportion of students choosing the STEM track around the cutoff in the control cohorts (cohorts 2008 and 2010). This is intuitive given the expected selection into re-taking the exam and scoring above the admission cutoff. In particular, this is likely to happen if there is a positive selection on ability and motivation, and high ability and high motivation students are more likely to choose the STEM track. On the other hand, there is a large discontinuity in the proportion of students choosing the STEM track at the cutoff in cohort 2009. Table 4 presents a local average treatment effect estimated using the RD design described above. The estimate is comparable to those from the reduced form specification: in C2009, those below the cutoff are up to 26 percentage points more likely to choose the STEM track relative to those just above the cutoff. The latter suggests that the estimate from the previous reduced form specification is robust.

Table 4: Robustness Check – RD Estimate

	Cohorts 2008 (Control)		Cohort 2009		Cohort C2010 (Control)	
Dep: Binary, in STEM	Female	Male	Female	Male	Female	Male
Above Cutoff	-0.0470***	-0.0524***	-0.238***	-0.266***	-0.00918	-0.0689***
	(0.00945)	(0.0138)	(0.00995)	(0.0122)	(0.0118)	(0.00746)
Bandwidth	0.850	0.316	0.272	0.321	0.336	0.561
N	46,428	70,648	51,620	130,958	84,938	153,182
Controls	×	×	×	×	×	×

NOTE: These estimates are from a Regression Discontinuity (RD) design comparing the field choices of students near the pre-college admission cutoff point. The outcome variable is whether the student is in STEM track. The running variable is Grade Point Average. In cohort 2009 (C2009), those above the admission cutoff point made their pre-college track choice before the announcement the policy reform. On the other hand, the ones below the cutoff made their pre-college track choice after the reform. Students in C2008 (both below and above the cutoff) made their track choices before the reform while those in C2010 (both below and above the cutoff) made their track choice after the reform. So, C2008 and C2010 are control cohorts. Optimal bandwidth selected based on Imbens and Kalyanaraman (2012). Other approaches give similar results. We used the triangular kernel. The result is robust to using other kernel types. *** p<0.01, ** p<0.05, * p<0.1

[23] Due to a preferential admission policy, the pre-college admission cutoff points for female and male students are different. We estimate the above specification for male and female students separately.

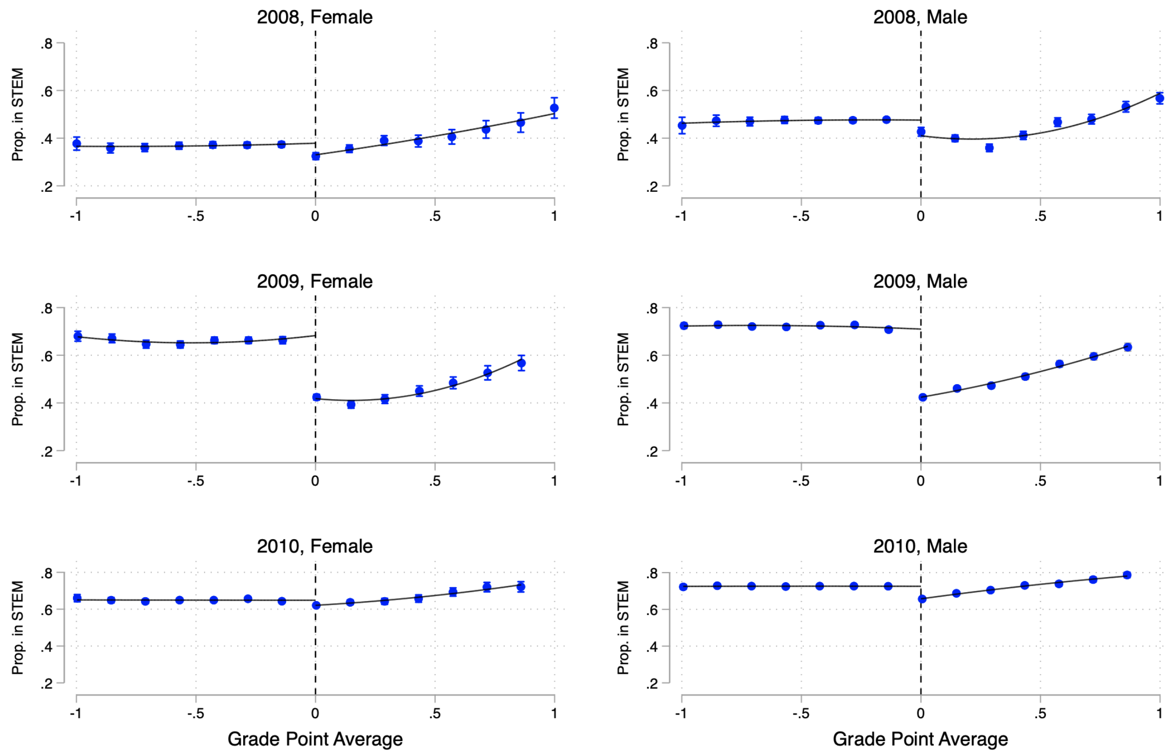

Figure 5: Regression Discontinuity Plots

Note: These graphs plot regression discontinuity (RD) estimates comparing the field choices of students near the pre-college admission cutoff point. The running variable is Grade Point Average of the student on pre-college entrance exam, re-centered at the admission cutoff. The vertical axis represents the proportion of students in STEM track. We find no evidence of manipulation at the cutoff. Covariates are balanced at the cutoff.

5.4 Sorting on Field Specific Skills

In this section, we study whether the admission policy reform (and the resulting change in admission selectivity) have led to sorting on field-specific skills. Understanding the sorting pattern and the characteristics of those induced by the policy reform to choose the STEM track is important for theoretical and policy purposes. In particular, the sorting pattern has an implication for the composition of students in different college fields and possibly for the quality of STEM education and labor force in general.[24] Moreover, this analysis is informative of the extent to which student choices are informed and whether their choices are consistent with theoretical predictions of self-selection models where skills and choices interact.

In a setting where choices and skills interact, economic theory predicts that individuals select themselves into different sectors based on their relative advantage in skills valued in those

[24] Bianchi (2020) studies the learning and labor market effects of change in the composition of students and provides an extensive discussion on channels through which this effect operates, including peer effects, quality of class instruction, resource dilution etc.

sectors (Willis and Rosen, 1979; Rosen, 1978; Roy, 1951). In this section, we use the complier analysis framework described in previous section to study the sorting induced by the policy reform (and the resulting change in admission selectivity). To do this, we first define two broad field-specific skills: *Science Skills* and *Humanities skills*. We define *Science Skills* as the average score of a student on the Mathematics, Physics, Chemistry, and Biology exams of the pre-college entrance exams. These exams test for skills considered useful in the college STEM fields. On the other hand, we compute *Humanities Skills* as the average score on Reading Comprehension, History, Geography, and Civic Education. We assume that skills tested on the latter exams are likely valued more in college social sciences and humanities fields.

We start our analysis by plotting these skills in a two-dimensional space. Figure 6 shows the distribution of students in the skills space. To see whether the distribution of students in the skills space has significantly changed over time, we plot the distribution for pre-reform and post-reform cohorts separately. Each circle in the plot is an actual skill combination in the analysis sample. The size of the circle represents the proportion of students with the skill combination represented by the point. This plot suggests two simple findings. First, it suggests that there is no significant change in the distribution of students in the skills space post-reform compared to pre-reform. Second, the plot suggests that the two skills are strongly positively correlated. Figure A.14 in the appendix supports this suggestive evidence. Theoretically, this strong positive covariance tends to result in hierarchical sorting, with the most productive students choosing the most preferred field (e.g. fields with higher wages)(Rosen, 1978). Furthermore, any factor that makes the most preferred field more attractive relative to others induces a positive selection on skills valued more in the field (Roy, 1951).

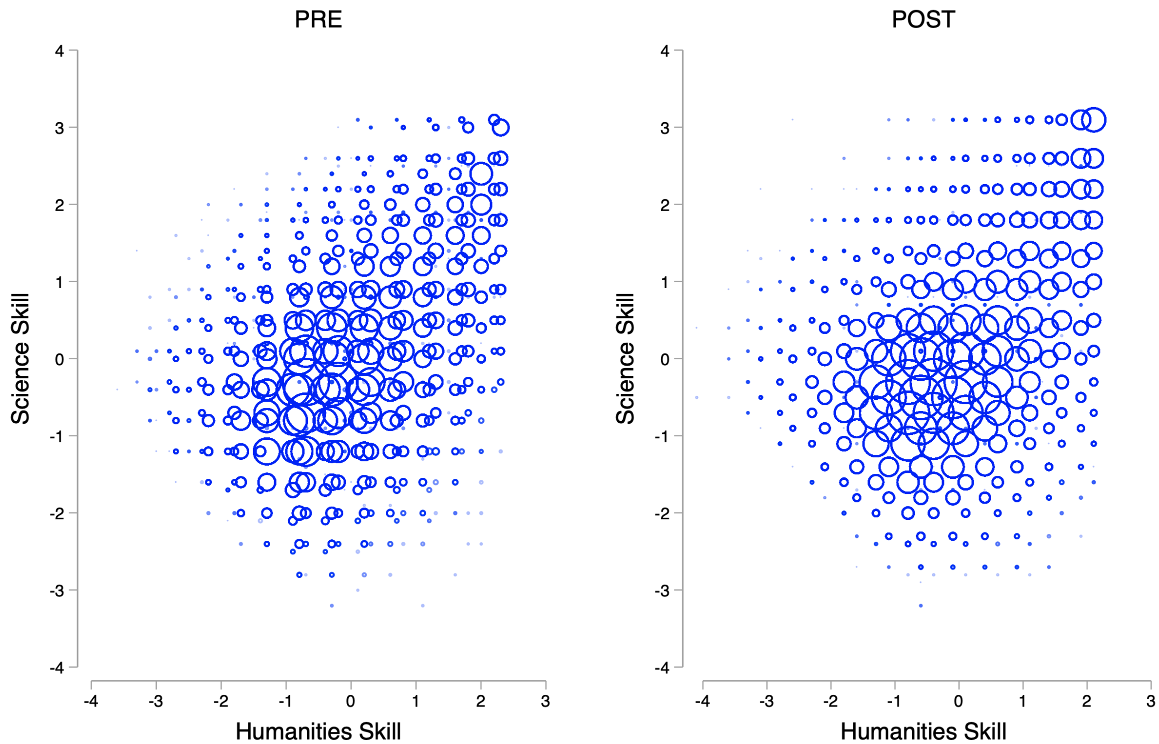

Figure 6: Distribution of Students in Skills Space

NOTE: These plots show the distribution of students in a field-specific skills space. Each circle is a Science and Humanities skills combination achieved by at least one student in the pre-college program. The size of the circle is proportional to the share of students at that specific skills combination. The left panel plots the skills combination for pre-reform cohorts and right panel plots the same for post reform cohorts. STEM skills are average score of the student on Science classes and Mathematics exams. Humanities skill is the average score on social science and reading comprehension exams.

Comparison of the sorting into tracks in the pre-reform and post-reform cohorts provides insight into the type of sorting caused by the policy reform. Figure 7 shows sorting on field-specific skills. In both panels, the skill combinations (represented by each circle) where the majority ($\geq 50\%$) of the students chose the STEM track are plotted in blue. On the other hand, the skill combinations where most students chose the Humanities track are plotted in red. For the panel on the right, the skill combinations of students most likely to have been induced by the reform to choose the STEM track are plotted in green. The plot (left panel) suggests that there is a strong selection on field-specific skills in pre-reform cohorts. In particular, STEM track students tend to have strong Science skills. Given the positive covariance between the two skills, these students also have strong Humanities skills. Therefore, in Roy (1951) terminology, the STEM track is the superior of the two tracks.[25] On the other hand, the Humanities track is populated mainly by students with low scores in both skills and only a few students with better Humanities skills.

[25] Although we do not have data on earnings for different fields from the local labor market, this finding is consistent with the general findings in the literature that, on average, STEM fields command significant earning premiums both in the US and other countries (Kirkeboen et al., 2016; Altonji et al., 2014, 2012).

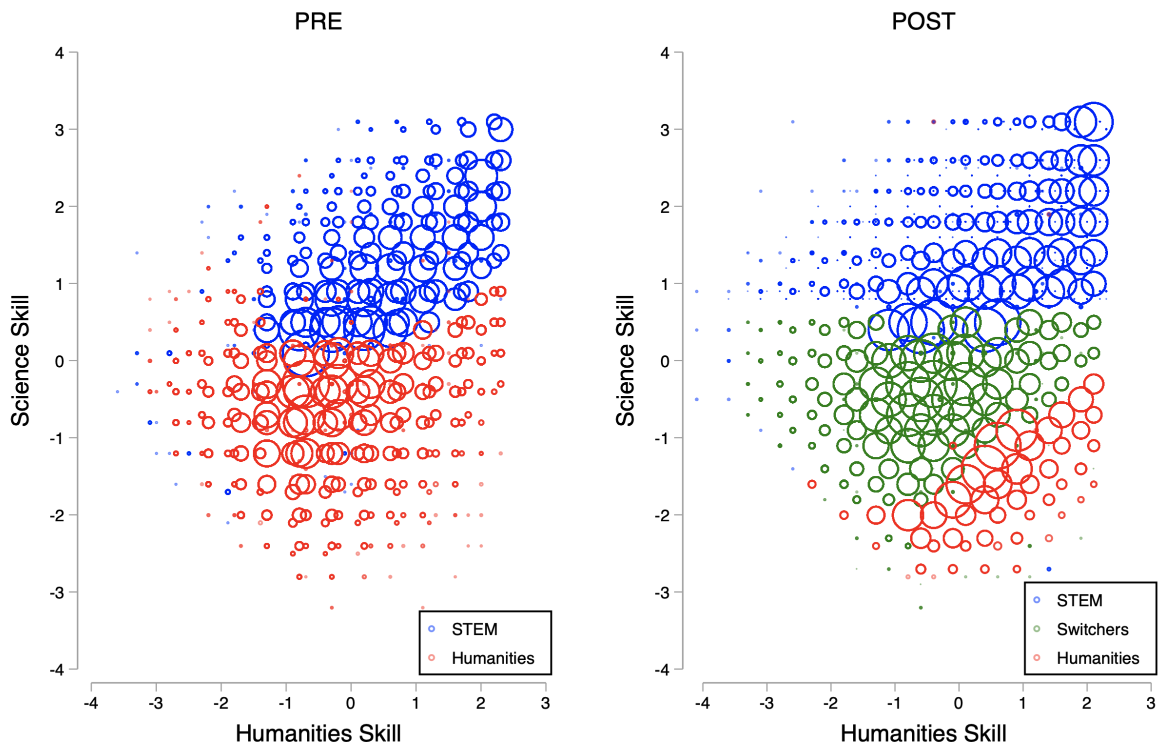

Figure 7: Distribution of Students in Skills Space – Sorting in to Tracks

NOTE: These plots show the distribution of students in a field-specific skills space. Each circle is a Science and Humanities skills combination achieved by at least one student in the pre-college program. The size of the circle is proportional to the share of students at that specific skills combination. The skill combinations where the majority of the students went to STEM track are plotted in blue. On the other hand, the skill combinations where the majority of the students went to Humanities track are plotted in red. For the panel on the left, the skills combination where students are most likely to have been induced by the reform to study STEM are plotted in green.

Consistent with our previous findings, Figure 7 (right panel) suggests that the reform drove large number of students to choose the pre-college STEM track. Most importantly, the plot shows that those induced by the reform to choose the STEM track are unlikely to be a random draw from the student population most likely to have chosen the Humanities track absent the reform. First, consistent with the findings in the previous section, those most likely to have been induced by the reform to choose the STEM track (plotted in green) are generally low-achieving students. Second, the plot suggests that switchers are relatively better in Science skills compared to students who chose to study the Humanities track post-reform. On the other hand, those who decided to study the Humanities track post-reform seem to be better in the Humanities skills relative to the switchers. Overall, this suggestive evidence is consistent with a prediction of Roy (1951) model where skills are significantly positively correlated, and the superior field becomes more attractive due to a favorable change in the outcome the agents are maximizing.

To formally study the sorting on field-specific skills, we compute the average characteristics of those induced by the reform to choose the STEM track, the *compliers*, using the approach laid out in Section 4.2. The average characteristics of the *compliers* is calculated as a weighted difference between the average characteristics of the student population in the STEM track in the post-reform cohorts and the average characteristics of those in the STEM track pre-reform. The result from this exercise is presented in Table 5. The *compliers* account for 23.8% of the analysis sample. This is comparable to the 24.3 percentage point increase in the STEM enrollment post-reform we obtained from the reduced form specification above. Regarding demographic characteristics, female students constitute 51% of the *complier* student population while they account for only 36% of the student population. While it is unclear what drives this selection on gender, female students are admitted to the pre-college program at a significantly lower admission cutoff point. Given the finding that marginal students are more likely to respond to the reform, this preferential admission policy can be one potential driver of this selection. Compared to the AT and the NT, the *compliers* are also more likely to have attended a private school at General High School and Pre-college.

Table 5: Complier Characteristics and Comparisons

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables	All	Always STEM (Always Takers)	Always Hum. (Never Takers)	Switchers (Compliers)	$H_0 : 2 = 4$	$H_0 : 3 = 4$	$H_0 : 2 = 3$
Proportion	1.000	0.467	0.294	0.238	–	–	–
Sex	0.356	0.273	0.436	0.508	-145.430	-35.725	64.099
Age	18.937	18.746	19.117	19.400	-144.676	-50.303	51.930
Private Sch. – GH	0.128	0.126	0.124	0.190	-54.468	-50.463	-1.013
Private Sch. – PP	0.088	0.092	0.085	0.102	-9.930	-16.132	-5.010
Retake Exam	0.019	0.015	0.024	0.033	-43.276	-16.557	11.940
Overall Skill	0.000	0.286	-0.284	-0.280	144.920	-1.263	110.000
Science Skill	0.000	0.327	-0.364	-0.263	159.655	-30.528	-140.000
Humanities Skill	0.000	0.127	-0.102	-0.159	75.505	15.053	-42.413
N	464,288	124,555	61,107	–	–	–	–

NOTE: The estimates are computed from complier characteristics analysis described in Section 4.2. Columns 2, 3 and 4 provide the average characteristics of students who would always go to STEM track, those who would always go to Humanities track and those who switched to STEM due to the reform respectively. The last three columns provide *t-stat* for two sample t-tests. The Overall, Science and Humanities skills are computed from standardized GPAs on all courses, science and mathematics courses, and social sciences and humanities courses respectively. *** p<0.01, ** p<0.05, * p<0.1

We find that the *compliers* are more likely to re-take the pre-college entrance exam relative to the other two groups. The latter is consistent with the finding from the reduced form specification that marginal students (and generally low-achieving students) are more likely to choose the STEM track post-reform. Most importantly, the result shows substantial sorting on field-specific skills. First, the AT have an absolute advantage in the Science and the Humanities skills relative to NT and the *compliers*. This hierarchical sorting into the STEM track is consistent with the strong positive correlation between the field-specific skills and suggests that the STEM track is a 'superior' field, in Roy (1951)'s terminology. Second, the *compliers* are better in Science skills relative to the NT, while the NT have better Humanities skills. The latter finding suggests that those induced by the reform to choose the STEM track are, on average, selected from the upper tail of the Science skills distribution of students.[26] Finally, although the *compliers* are better at Science skills relative to NT, they are substantially poorer in both Science and Humanities skills compared to the average AT.

In sum, with the above findings, we highlighted two layers of selection. The selection into the pre-college tracks before the reform is best described by hierarchical sorting *i.e.* students in the pre-college STEM track have an absolute advantage in both Science and Humanities skills.[27] On the other hand, the policy reform and the resulting change in admission selectivity in the two tracks led to a positive selection on field-specific skills: those induced by the reform to choose the STEM track are better in skills valued more in college STEM fields. This selection on field-specific skills implies that students are not naively sorting into a less selective college field. Specifically, the selection suggests that students understand their relative skill advantage in different academic tracks and its implication for their college admission probability. Most importantly, it suggests that students take this into account in their field choice decisions. This finding also highlights the role of multidimensional skills (abilities) in students' field choice decision. Our finding is interesting given that the literature on the determinants of field choice focuses on the role of overall skill (ability).[28]

This sorting pattern described above has implications for the overall and field-specific peer quality in the two academic tracks and potentially in different college fields. In particular, the sorting pattern implies that the STEM track experiences a significant decrease in average peer quality in the Science and Humanities skills. On the other hand, the above result predicts the average Science skills to decrease in the Humanities track, while the opposite is expected for Humanities skills. We study the overall and field-specific peer qualities in the two academic tracks to test these predictions and as a robustness check for the complier analysis. Table 6 presents a simple comparison of the field-specific skills in the two tracks in cohorts before and after the reform. The results are intuitive and consistent with the sorting patterns discussed above. We find that the average Science and Humanities skills in the STEM track are larger than the corresponding averages in the underlying student population, both before and after reform. On the other hand, the opposite is true for the Humanities track: the average skills are smaller than the corresponding averages in the population. The latter result is consistent with the hierarchical sorting described above.

[26] We also use basic machine learning algorithm to get the approximate distribution of both skills for the AT, the NT and the *compliers*. The result, presented in Figure A.15, is consistent with the findings from the complier analysis.

[27] As discussed above this type of sorting into fields requires large positive correlation between skills valued in each field. Our data shows a simple correlation between Science and Humanities skills is close to 0.53.

[28] Some exceptions highlighting the role of multidimensional skills include Humphries et al. (2019), Kirkeboen et al. (2016) and Altonji (1993).

Table 6: Average Skills in STEM and Humanities Tracks: PRE vs POST

	PRE REFORM			POST REFORM			*t*-Stat	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Track → Skills ↓	*All*	*Humanities*	*STEM*	*All*	*Humanities*	*STEM*	$H_0 : 2 = 5$	$H_0 : 3 = 6$
Overall Skill	0.000	-0.275	0.292	0.000	-0.290	0.119	-0.009** (-2.299)	-0.173*** (-42.093)
Science Skill	0.000	-0.320	0.340	0.000	-0.374	0.153	-0.044*** (-10.979)	-0.187*** (-47.014)
Humanities Skill	0.000	-0.128	0.136	0.000	-0.105	0.043	0.025*** (5.657)	-0.093*** (-23.279)
Correlation	0.522	–	–	0.514	–	–	–	–

NOTE: The estimates are average of Overall, Science and Humanities skills of students in STEM, Humanities and both tracks, before and after the reform. The last two columns compare the average skills of students before and after the reform in each track tracks (provide *t-stat* for two sample t-tests). The Overall, Science and Humanities skills are computed from standardized GPAs on all courses, science and mathematics courses, and social sciences and humanities courses respectively. *** p<0.01, ** p<0.05, * p<0.1

We find that overall peer quality falls in both tracks after the reform. This is consistent with the finding that the policy reform drove mostly low-achieving students to choose to specialize in the STEM track and that the *compliers* are marginally better than the NT. Moreover, consistent with earlier findings, we find a substantial decrease in the average Science skills in both tracks post-reform. One interesting finding is that the decrease in average Sciences skills is considerably larger in the STEM track, although the reform induced a positive selection on Science skills. This is mainly because of the strong selection on Science skills in the pre-reform cohorts. Finally, our result shows that the average Humanities skills substantially increased in the Humanities track, again consistent with the finding that the *compliers* are poor in Humanities skills relative to the NT. Overall, these findings suggest that the sorting pattern substantially affected the average peer qualities of students in both tracks. The findings also suggest that the results from the complier analysis are robust.

5.5 How Did the Compliers Fare in College Admission

In this section, we study the college admission outcomes of those induced by the policy to choose the STEM track. In particular, we are interested in the counterfactual admission outcome of the *compliers*: how would they have fared had they stayed in the Humanities track compared to their outcome in the STEM track? Although college STEM fields were allocated 20 percentage points more seats post-reform, it is unclear whether this translates to higher admission probabilities for the *compliers*. The STEM track is oversubscribed even before the reform. Moreover, the *compliers* compete for college admission with the AT, a group with a substantial advantage in both field-specific skills. The *compliers'* counterfactual admission outcome is also informative of whether the average *complier's* decision to switch to the STEM track is ex-post rational.

Using detailed academic records and demographic characteristics, we estimate the counterfactual admission probability of the *compliers*, the AT, and the NT. First, we estimate the logit of admission outcome (admitted or rejected) on detailed academic records in a relevant counterfactual case (sample). Then we use the coefficients from this estimation and the average characteristics of the group for which we are predicting to obtain the counterfactual admission probability. The result from this exercise is presented in Table 7. For the AT and the NT, we estimate the counterfactual admission probability under the new and the old admission regimes, respectively. The result shows that the AT gained 15 percentage points in the probability of admission. On the other hand, the NT lost 6 percentage points in the probability of college admission. This finding is intuitive given that the reform re-distributes college seats from social sciences and humanities fields to STEM fields.

Table 7: Counterfactual Admission Probability

	(1)	(2)	(3)	(4)
Variables	All	Always STEM (Always Takers)	Always Humanities (Never Takers)	Switchers (Compliers)
Proportion	1.000	0.467	0.294	0.238
Exam Score [0-100]	49.577	52.405	47.022	44.48
Admission Rate	0.730	0.740	0.680	0.820
Exam Score: Post, Humanities	–	–	–	[45.927]
Admission Rate: Post, Humanities	–	–	–	[0.693]
Exam Score: Post, STEM	–	[51.948]	–	–
Admission Rate: Post, STEM	–	[0.892]	–	–
Exam Score: Pre, Humanities	–	–	[48.318]	[47.603]
Admission Rate: Pre, Humanities	–	–	[0.737]	[0.717]
Exam Score: Pre, STEM	–	–	–	[46.811]
Admission Rate: Pre, STEM	–	–	–	[0.680]
N	350,560	66,534	61,107	–

Note: First we estimate the following logistic regression: $y_i = \alpha + \sum_{k=1}^{7} \gamma_k \cdot COURSE_K + X'\Gamma + \xi_i$ where y_i is whether individual i is admitted to college or not, or exam score on college admission exam; $COURSE$ is subject level score of the student on pre-college entrance exam, X includes student level controls and school level controls. We predict the probability of admission of the average complier under the counterfactual case 'post-reform and in Humanities track' using the average characteristics of compliers estimated from the complier analysis..

For the *compliers*, we estimate the counterfactual admission probability assuming they stayed in the Humanities track under the new admission policy. One potential concern with this estimate is that the coefficients estimated using a sample of students in the Humanities track post-reform are unlikely to be unbiased counterfactual estimates. Specifically, under the counterfactual case, there will be more students in the Humanities track, and the admission rate will likely be substantially lower. However, this makes the counterfactual admission rate from this approach an upper bound, and the *compliers'* admission gain a lower bound estimate.[29] Comparing this estimate to the actual probability of college admission shows that the *compliers* gained at least 12 percentage points in admission probability by switching to the STEM track. Overall, this suggests that the reform re-distributed college seats from students with comparative advantage in Humanities skills to those with comparative advantage in Science skills. As a result, the AT and the *compliers'* gained significant admission probability while the NT lost. Furthermore, assuming students are maximizing their college admission probability, this finding suggests that the average *complier's* decision to switch to the STEM track was ex-post rational decision.[30]

6 Conclusion

This paper examines the effect of college admission selectivity on students' college field choice in a centralized, field-specific college admission system. The identification strategy leverages a college admission policy reform in Ethiopia that sharply increased the proportion of college seats in public universities allocated to college STEM fields at the expense of those in social sciences and humanities. The reform decreased the admission selectivity of college STEM fields significantly. The study shows that students are significantly more likely to choose the pre-college STEM track post-reform. In addition, the result indicates that academically marginal students respond more strongly relative to the infra-marginal students. The study also documents a substantial sorting on field-specific skills. Given that the reform is unlikely to change a student's perception of her ability or expected performance, the result implies that college admission concerns drive the sharp increase in the probability of choosing the pre-college STEM track.

The finding in this study implies that, in a field-specific college admission system, college admission concerns play a crucial role in students' college field choices. However, students are not naively sorting into less selective college fields. The field-specific sorting into tracks described in this study suggests that students understand their relative skill advantage in different college fields and its implication for their college admission outcome. This finding contrasts with previous studies suggesting that students are often not well-informed about crucial variables necessary to make human capital investment decisions, including their ability and expected performance in different college fields (Shorrer and Sóvágó, 2018; Hastings et al., 2016; Huntington-Klein, 2015). On the other hand, the sorting pattern is consistent with the predictions of models of self-selection (Willis and Rosen, 1979; Rosen, 1978; Roy, 1951).

[29] Note that in this case, the admission probability gain of the AT and the admission probability loss of the NT are likely to be larger.

[30] Note that the admission gains and losses of the *compliers*, the AT and the NT do not need to add up to 0. This is because the counterfactual cases for all three estimates are not the same. The counterfactual cases for the AT and the NT are 'post-reform' and 'pre-reform', respectively. On the other hand, the counterfactual case for the *compliers* is 'post-reform but the *compliers* stay in the Humanities track'. Note also that if the latter counterfactual case materializes for the *compliers*, the admission gains and losses estimated above for the AT and the NT are likely to change.

The findings in this study have implications for large policy reforms that expand college seats in specific fields. In particular, the selection on field-specific skills documented here suggests that these reforms can have substantial unintended consequences for the quality of students enrolled in different fields and, ultimately, for the quality of the labor force in the long run. This is particularly important in light of the often discussed policy sentiment that an increase in the number (and proportion) of college science and technology graduates is necessary to promote economic growth and gain competitive advantage in the global economy (Stinebrickner and Stinebrickner, 2014; COSEPUP, 2007). While the merit of such policy recommendation is beyond the scope of this study, our finding implies that the marginal student enrolled post expansion is unlikely to be of the same quality as the average student in these fields before expansion. This, in turn, can substantially affect the learning and labor market outcomes of both the marginal and infra-marginal students. Consequently, the average quality of the labor force in the local labor market can also be significantly affected.

The findings in this study suggest some interesting research questions that I plan to pursue as separate research projects in future work. One main finding in this study is that the reform led to a significant sorting on field-specific skills, resulting in a substantial change in the overall and field-specific peer qualities of students in the pre-college academic tracks. One potential research question is to study the effects of this change in peer quality on students' pre-college, college, and labor market outcomes. While peer effects in school and labor market outcomes have been studied, our context offers a richer setting to study peer effects in learning and labor market outcomes. This setting allows measuring field-specific peer quality instead of overall peer quality (ability). The latter is particularly crucial in estimating peer effects in college outcomes since topics covered in different college fields demand different sets of skills. Further, this setting allows to study potential non-linearity in peer effects across student ability distribution.

References

Abadie, A. (2003). Semiparametric instrumental variable estimation of treatment response models. *Journal of econometrics*, 113(2):231–263.

Abdulkadiroğlu, A., Che, Y.-K., and Yasuda, Y. (2011). Resolving conflicting preferences in school choice: The" boston mechanism" reconsidered. *American Economic Review*, 101(1):399–410.

Almond, D. and Doyle, J. J. (2011). After midnight: A regression discontinuity design in length of postpartum hospital stays. *American Economic Journal: Economic Policy*, 3(3):1–34.

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

Altonji, J. G., Blom, E., and Meghir, C. (2012). Heterogeneity in human capital investments: High school curriculum, college major, and careers. *Annu. Rev. Econ.*, 4(1):185–223.

Altonji, J. G., Kahn, L. B., and Speer, J. D. (2014). Trends in earnings differentials across college majors and the changing task composition of jobs. *American Economic Review*, 104(5):387–93.

Angrist, J. D. and Imbens, G. W. (1995). Two-stage least squares estimation of average causal effects in models with variable treatment intensity. *Journal of the American statistical Association*, 90(430):431–442.

Arcidiacono, P. (2004). Ability sorting and the returns to college major. *Journal of Econometrics*, 121(1-2):343–375.

Attanasio, O. P. and Kaufmann, K. M. (2017). Education choices and returns on the labor and marriage markets: Evidence from data on subjective expectations. *Journal of Economic Behavior & Organization*, 140:35–55.

Bianchi, N. (2020). The indirect effects of educational expansions: Evidence from a large enrollment increase in university majors. *Journal of Labor Economics*, 38(3):767–804.

Bleemer, Z. and Mehta, A. (2021). College major restrictions and student stratification.

Bond, T. N., Bulman, G., Li, X., and Smith, J. (2018). Updating human capital decisions: Evidence from sat score shocks and college applications. *Journal of Labor Economics*, 36(3):807–839.

Bordon, P. and Fu, C. (2015). College-major choice to college-then-major choice. *The Review of economic studies*, 82(4):1247–1288.

Bound, J., Hershbein, B., and Long, B. T. (2009). Playing the admissions game: Student reactions to increasing college competition. *Journal of Economic Perspectives*, 23(4):119–46.

Broussard, N. and Tekleselassie, T. G. (2012). Youth unemployment: Ethiopia country study. *International Growth Centre. Working Paper*, 12(0592):1–37.

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

Chen, Y. and Kesten, O. (2019). Chinese college admissions and school choice reforms: An experimental study. *Games and Economic Behavior*, 115:83–100.

COSEPUP (2007). *Committee on Science and Engineering and Public Policy, Rising above the gathering storm: Energizing and employing America for a brighter economic future*. National Academies Press Washington, DC.

Daysal, N. M., Trandafir, M., and Van Ewijk, R. (2015). Saving lives at birth: The impact of home births on infant outcomes. *American Economic Journal: Applied Economics*, 7(3):28–50.

Estevan, F., Gall, T., Morin, L.-P., et al. (2019). Can affirmative action affect major choice? Technical report.

Goodman, J., Gurantz, O., and Smith, J. (2020). Take two! sat retaking and college enrollment gaps. *American Economic Journal: Economic Policy*, 12(2):115–58.

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

Humphries, J. E., Joensen, J. S., and Veramendi, G. F. (2019). Complementarities in high school and college investments. *Unpublished manuscript*.

Huntington-Klein, N. (2015). Subjective and projected returns to education. *Journal of Economic Behavior & Organization*, 117:10–25.

Imbens, G. and Kalyanaraman, K. (2012). Optimal bandwidth choice for the regression discontinuity estimator. *The Review of economic studies*, 79(3):933–959.

International Labour Organization (2016). Key indicators of the labour market. 9th ed.

Joshi, R. and Verspoor, A. (2012). *Secondary education in Ethiopia: Supporting growth and transformation*. World Bank Publications.

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

MOE (2005). Education sector development program iii (2005/2006–2010/2011).

MOE (2008). Annual intake and enrollment growth and professional mix of ethiopian public higher education: Strategy and conversion plan, 2001 – 2005.

MOE (2018). Ethiopian education development roadmap (2017-30)– an integrated executive summary.

Montmarquette, C., Cannings, K., and Mahseredjian, S. (2002). How do young people choose college majors? *Economics of Education Review*, 21(6):543–556.

Mussa, M. (2005). Civil service employment and pay in ethiopia: Challenges for service delivery and achieving the mdgs. *World Bank Group*.

Pallais, A. (2015). Small differences that matter: Mistakes in applying to college. *Journal of Labor Economics*, 33(2):493–520.

Robinson, M. and Monks, J. (2005). Making sat scores optional in selective college admissions: A case study. *Economics of Education Review*, 24(4):393–405.

Rosen, S. (1978). Substitution and division of labour. *Economica*, 45(179):235–250.

Roy, A. D. (1951). Some thoughts on the distribution of earnings. *Oxford economic papers*, 3(2):135–146.

Salmi, J., Sursock, A., and Olefir, A. (2017). Improving the performance of ethiopian universities in science and technology: A policy note. *World Bank Group*.

Seid, Y., Taffesse, A. S., and Ali, S. N. (2015). *Ethiopia: An agrarian economy in transition*. Number 2015/154. WIDER working paper.

Shorrer, R. I. and Sóvágó, S. (2018). Obvious mistakes in a strategically simple college admissions environment: Causes and consequences. *Available at SSRN 2993538*.

Silliman, M. and Virtanen, H. (2022). Labor market returns to vocational secondary education. *American Economic Journal: Applied Economics*, 14(1):197–224.

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

Stinebrickner, R. and Stinebrickner, T. R. (2014). A major in science? initial beliefs and final outcomes for college major and dropout. *Review of Economic Studies*, 81(1):426–472.

Wang, A., Wang, S., and Ye, X. (2021). Cognitive limitation in complex decision-making: Evidence from centralized college admission.

Willis, R. J. and Rosen, S. (1979). Education and self-selection. *Journal of political Economy*, 87(5, Part 2):S7–S36.

World Bank (2007). Ethiopia: Urban labor markets, challenges and prospects, volume 1. synthesis report. *World Bank Group*.

Zafar, B. (2013). College major choice and the gender gap. *Journal of Human Resources*, 48(3):545–595.

Appendix

A Additional Figures and Tables

A.1 The High School Structure in Ethiopia

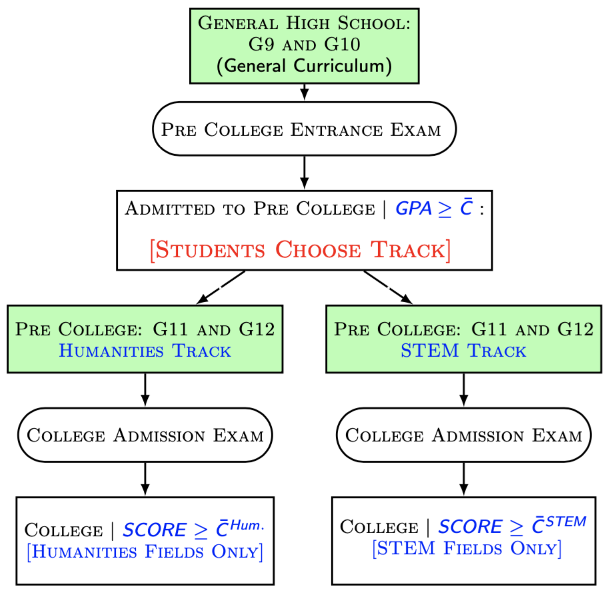

Figure A.1: The High School System in Ethiopia

A.2 College Admission Cutoff Points - By Track

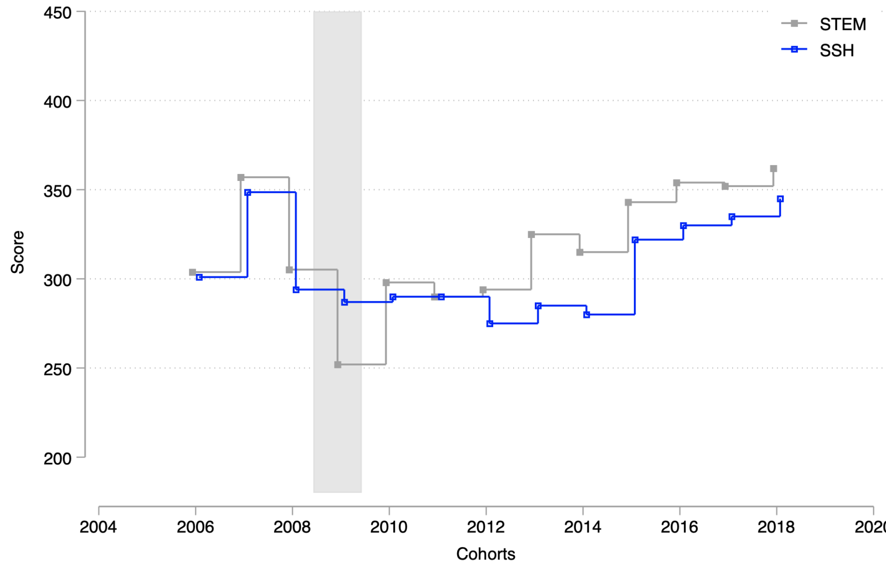

Figure A.2: College Admission Cutoff Points for Male Students

Note: The above plot shows college admission cutoff points by academic track for male students. The cutoff points for cohorts 2009 - 2018 are received from the Ministry of Education (MOE) of Ethiopia and National Educational Assessment and Examination Agency of Ethiopia (NEAEA). The cutoff points for cohorts 2006-2008 are imputed from Ethiopian public college freshmen enrollment data published by the MOE in Educational Statistics Annual Abstract modules 2006, 2007 and 2008. Consequently, the cutoff points may not be as accurate as the actual cutoff points applied to admit students to college in those years. However, the relative position of STEM and SSH track cutoff points, which is the subject of interest here, is likely to be accurate.

A.3 Reform and Cohorts – Illustration of Timeline

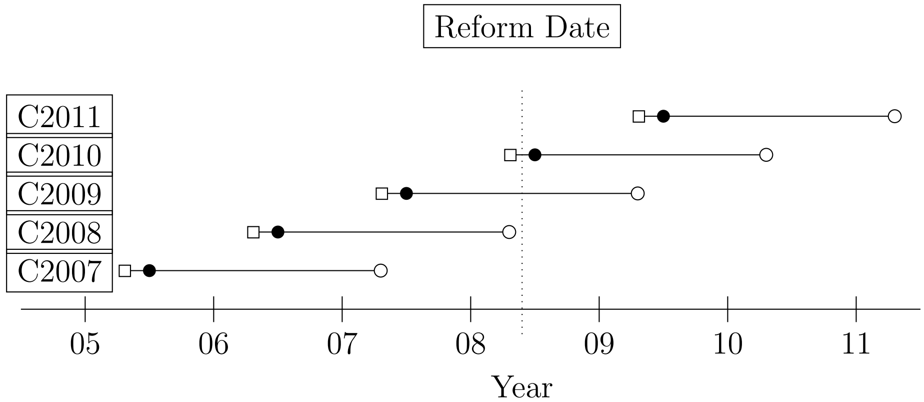

Figure A.3: Reform and Cohorts – Illustrative Timeline

Note: This diagram illustrates treatment statuses of different cohorts (C2007, C2008, C2009, 2010 and C2011). The hollow square for each cohort shows the year and month of the pre-college entrance exam, which is usually in June or July each year. Students make their pre-college academic track choice in September the same year after receiving their score on the exam. This is indicated by the solid black circle for each cohort. The hollow circle indicates the year and month of the college entrance exam, which is usually in June or July, two years after pre-college entrance exam. The college admission reform is announced in August 2008. Cohorts C2007, C2008 and C2009 made their pre-college academic track choice decisions before the reform. Only C2010 and later cohorts had the opportunity to incorporate the new policy in to their track choice decisions. In other words, although the reform starts to take effect on C2009, only C2010 and later can change their track choice decisions in response to the reform.

A.4 Share of College Seats to General High School and Pre College Enrollment

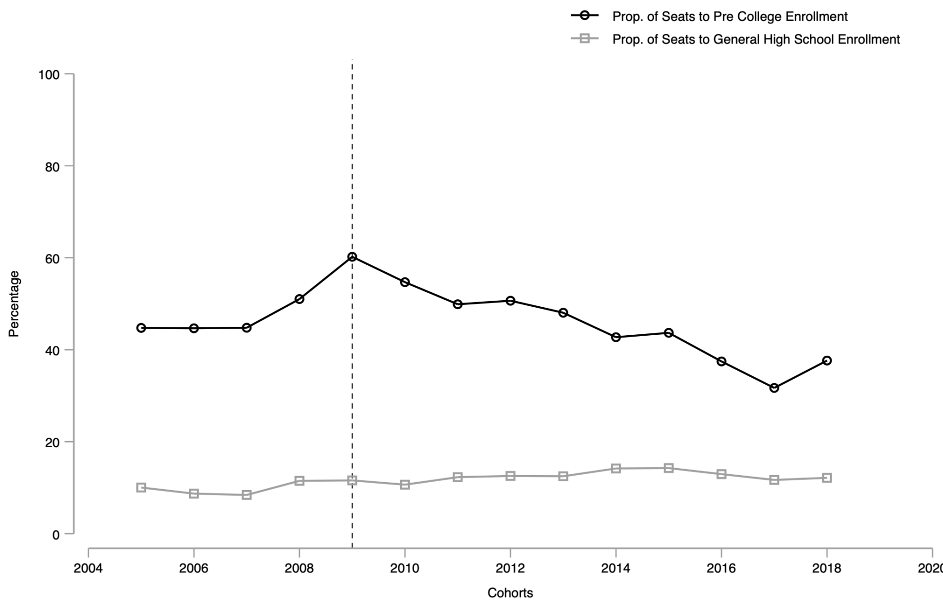

Figure A.4: Prop. of College Seats to Enrollment in Pre College and General High School

A.5 Distribution of Overall, STEM and Humanities GPAs, by Track

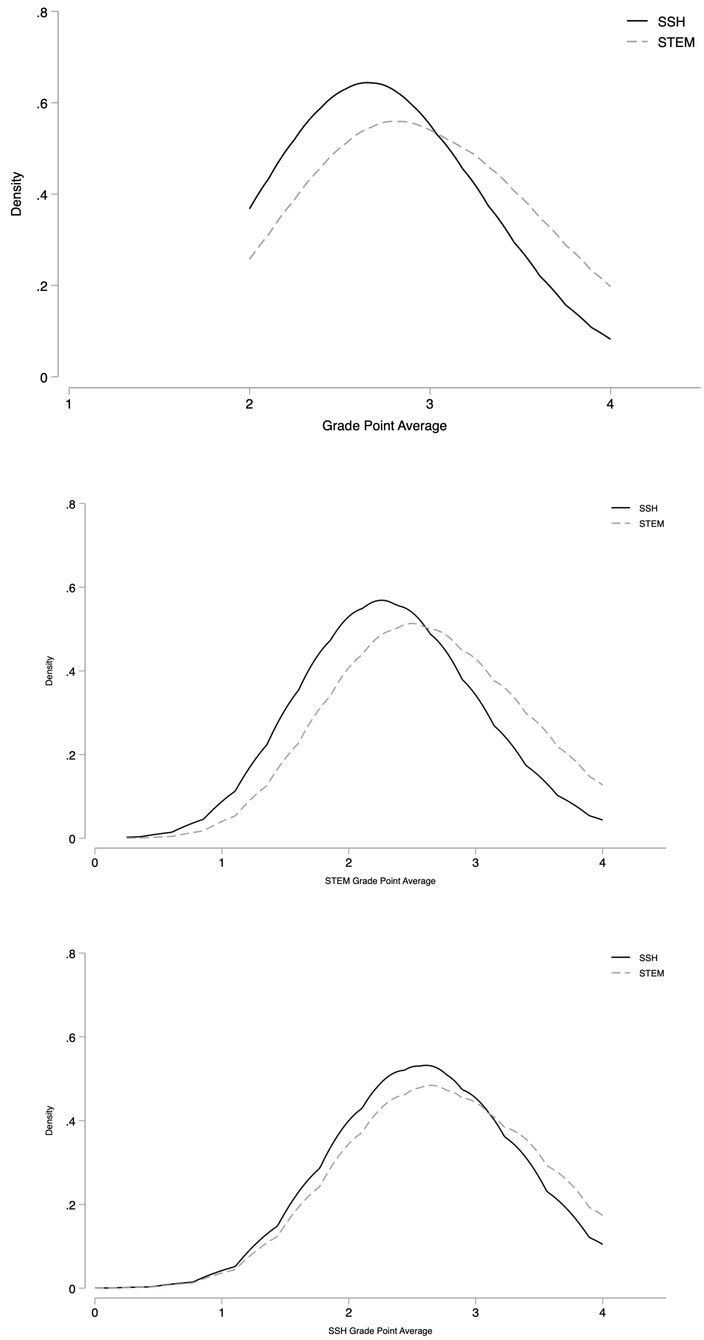

Figure A.5: Distribution of Overall GPA, STEM GPA and Humanities GPA by Track

A.6 Demographic Characteristics and Academic Records

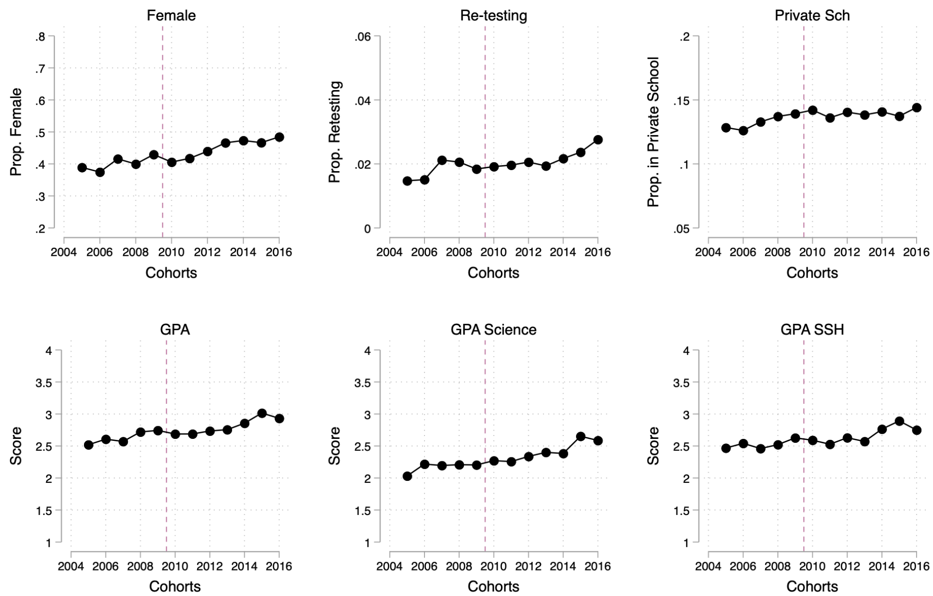

Figure A.6: Demographic and Other Characteristics

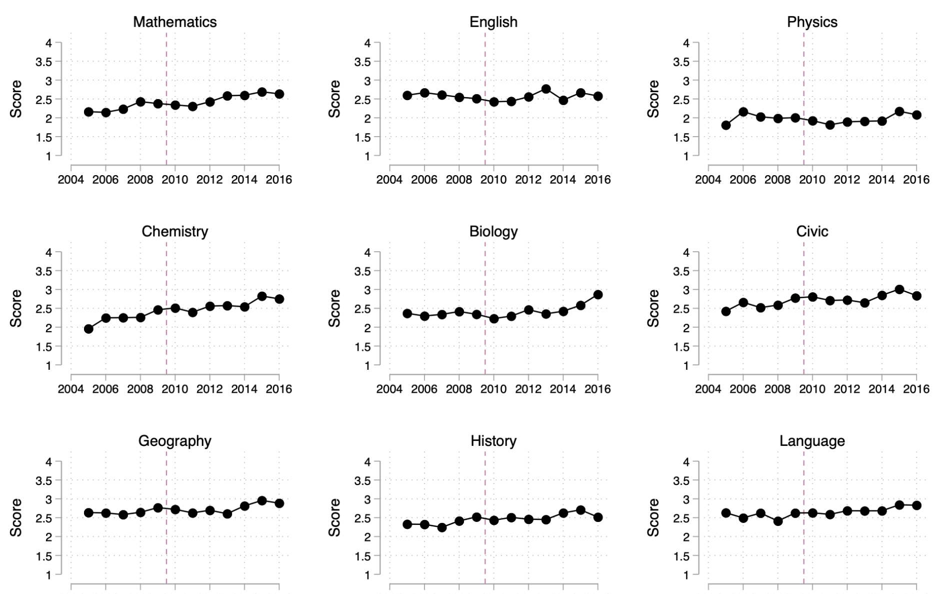

Figure A.7: Subject Level Score on Pre-College Admission Exam

A.7 Pre-college Attendance and Cohort Manipulation

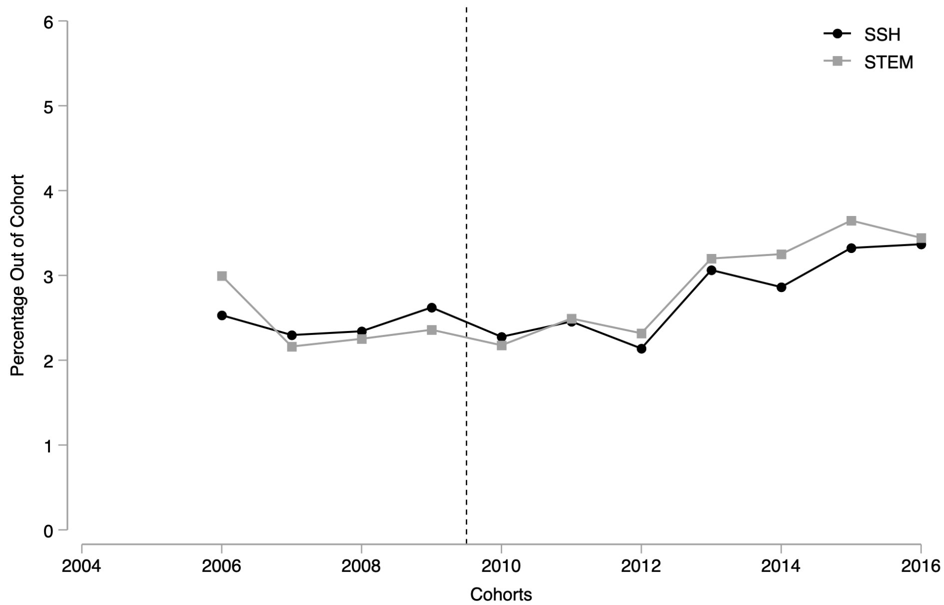

Figure A.8: Percentage of Students Out of Cohorts

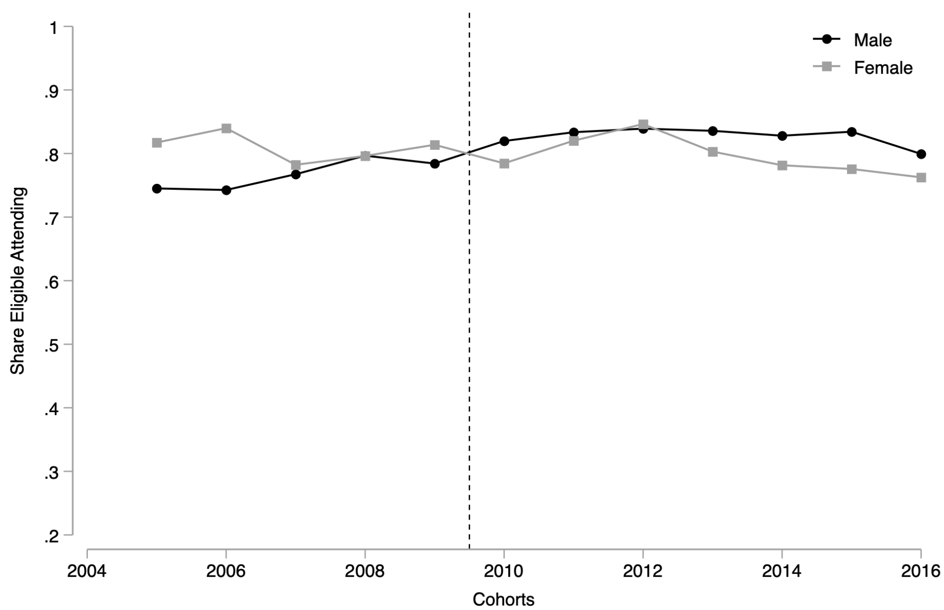

Figure A.9: Share of those eligible attending the pre-college

A.8 RD Raw Plot

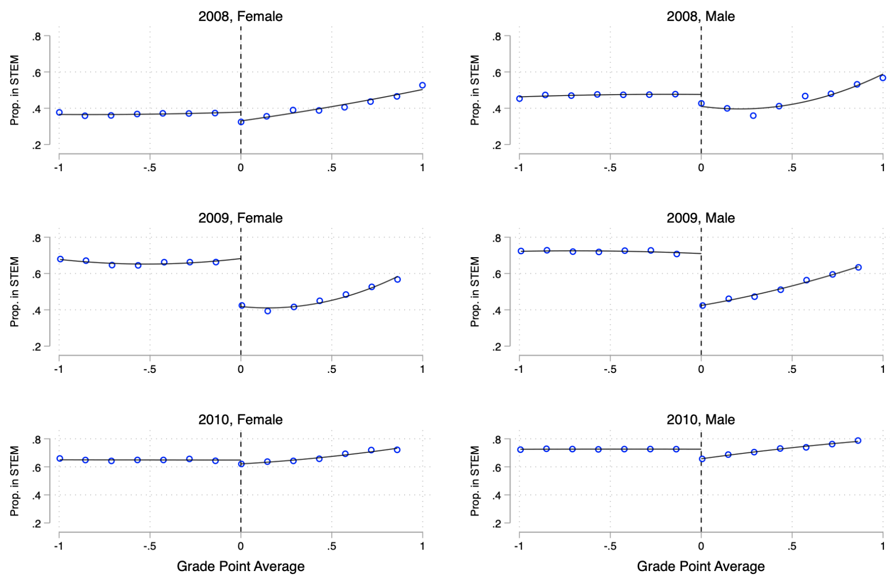

Figure A.10: RD Raw Plot

A.9 RD Density Test

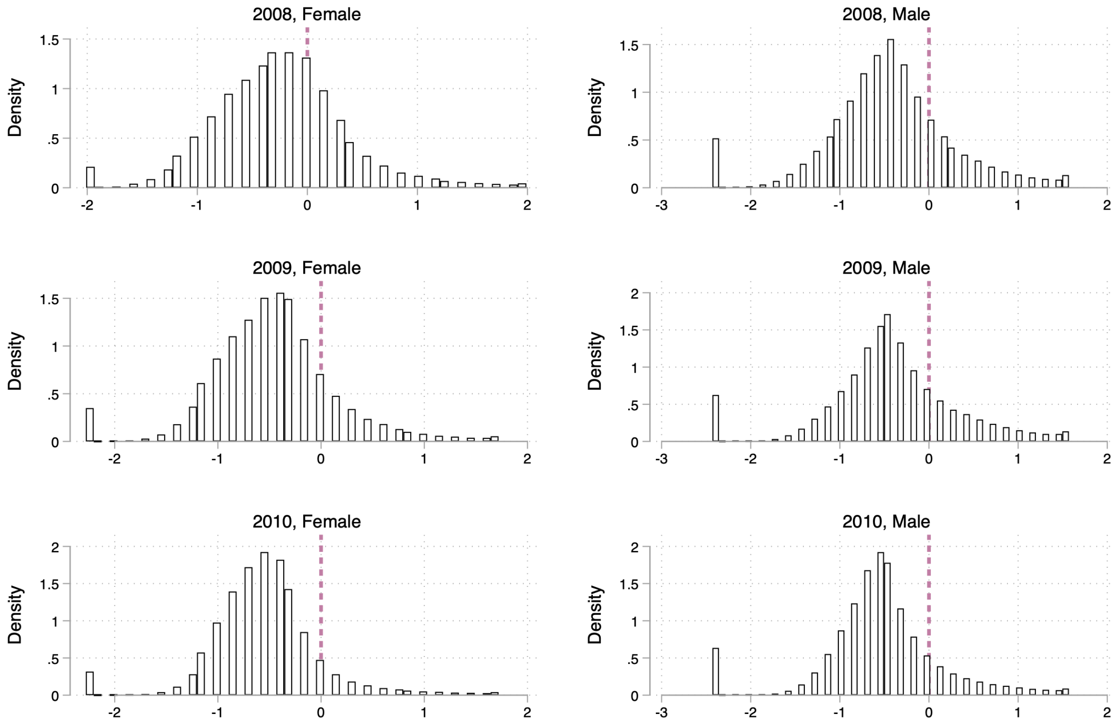

Figure A.11: Histogram of Grade Point Average

A.10 RD Covariate Balance

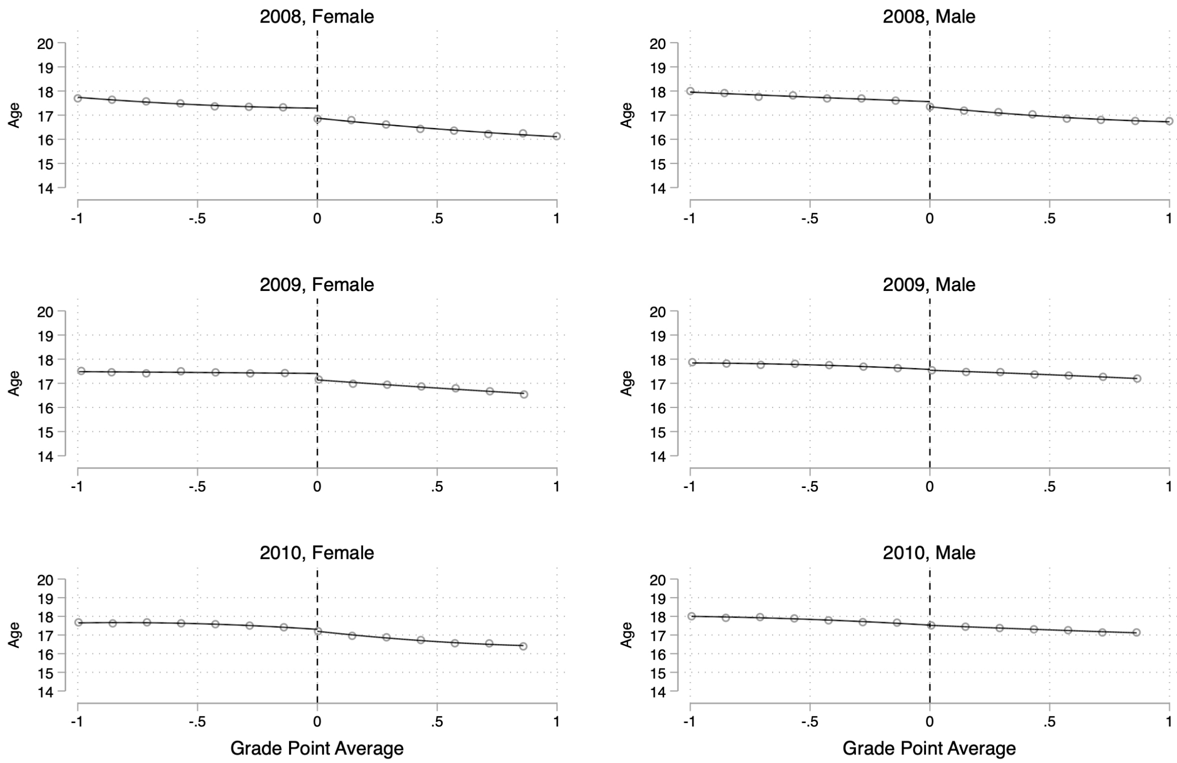

Figure A.12: Covariate Balance – AGE

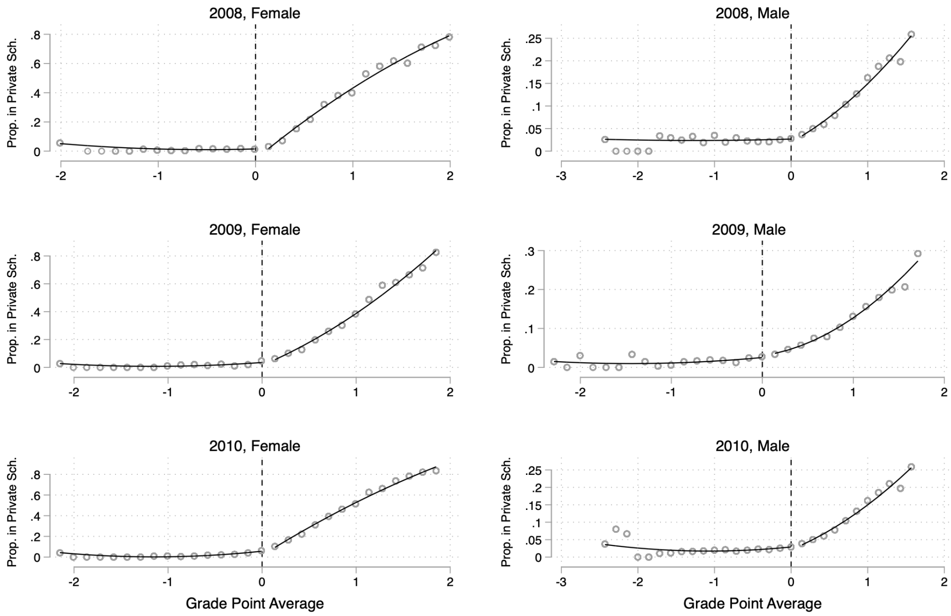

Figure A.13: Covariate Balance – Private School

A.11 Robustness Check – Regression Discontinuity Design

A.12 Correlation Between STEM and Humanities Skills

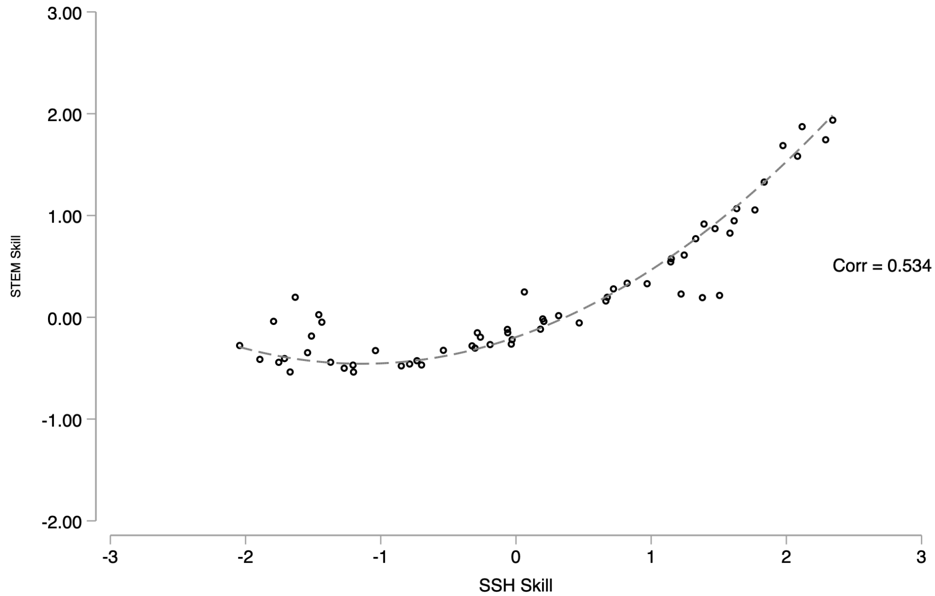

Figure A.14: Correlation Between the Two Field Specific Skills

A.13 Skill Distribution of the AT, the NT and the Compliers

We follow Bleemer and Mehta (2021) and use machine learning technique to compute intended academic track for students who choose their academic track after the announcement of the reform from a detailed academic records and demographic characteristics of students. The algorithm is trained on pre-reform data using general high-school grades and demographic characteristics. The trained algorithm is used to compute predicted probability of choosing STEM track for all students who went to pre-college program after the reform (here we present the estimation from Cohort 2010 only). We define *always takers* as those students with high predicted probability of choosing STEM track based on their characteristics and academic preparations and also actually went to STEM track. Similarly, *never takers* are those students with very low predicted probability of choosing STEM and also choose to study SSH after the reform. Finally, *compliers* those with with very low predicted probability of choosing STEM but went to study STEM in pre-college program. While this definitions are not expected to precise and meant only to provide suggestive evidence, the result is consistent with the complier analysis in main sections.

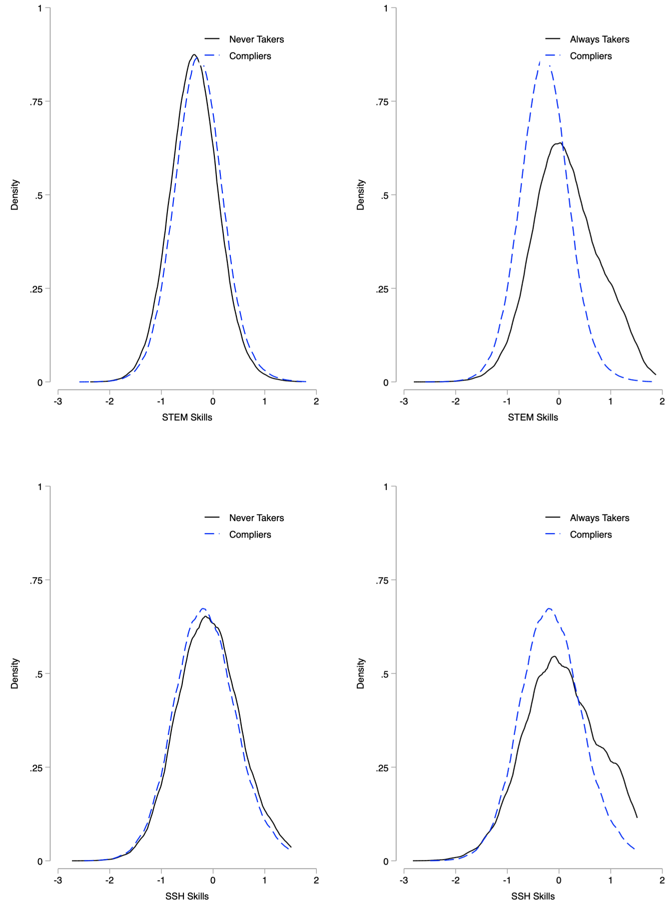

Figure A.15: Distribution of Skills for AT, NT and Compliers

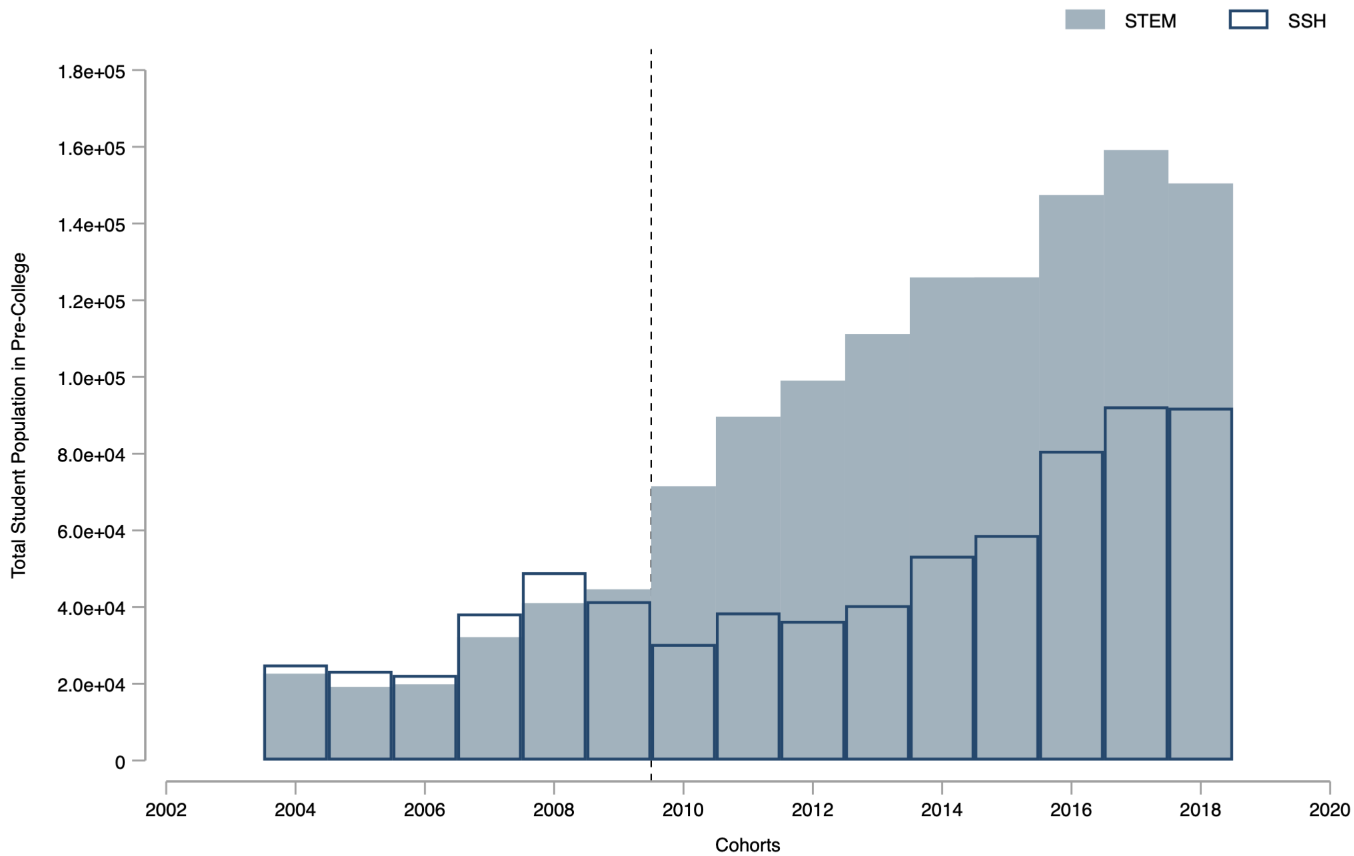

Figure A.16: Student Population in SSH and STEM Tracks

: