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ABSTRACT

Does It Pay to Attend More Selective High Schools? Regression Discontinuity Evidence from China*

We examine the effect of attending academically selective high schools on test scores, by leveraging administrative data that matches high school preferences of the population of urban middle school graduates in one Chinese prefecture in 2010 with high school student records. The standard admission channel is generally driven by merit subject to only nominal tuition fees, with contextual admission for disadvantaged students. An alternative admission channel admits lower-ability students subject to substantial selection-fees, retained by the under-funded schools. We combine a cumulative multiple-cutoff regression discontinuity design (RDD) with a within-cutoff normalizing-and-pooling fuzzy RDD strategy, based on publicly announced school-specific admission thresholds in the city-wide High School Entrance Exam (HSEE) scores. Multiple-cutoff RDD estimates show heterogeneous effects of attending schools with different degrees of selectivity, in a unified setting. Within-cutoff normalizing-and-pooling RDD allows admission thresholds to differ by willingness to pay the extra selection-fees and by eligibility for contextual admission. The estimated effects on high school leaving exam scores of attending elite schools vs normal public high schools, and of attending normal public high schools vs low-quality private high schools are insignificantly different from zero, for students who barely made it into the more selective school. However, the effect of attending the most selective flagship school vs elite schools, has a large negative and statistically significant effect, which is more pronounced for girls, for students from the semi-urban area according to hukou (household) registration, and for students who performed relatively badly in the science track subjects in the HSEE.

JEL Classification: I20, I24

Keywords: elite schools, school choice, fuzzy regression discontinuity design, China

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1. Introduction

Academically selective admissions to publicly funded schools are common in both developed and developing countries: for example, “exam schools” in the US, “grammar schools” in the UK, and “key schools” in China. In many places, selection by ability is limited to post-compulsory education. By the very nature of selection by ability, students in academically selective elite schools will have peers with higher academic ability, on average, than their counterparts who attend non-elite schools - even in the absence of differences in other inputs into the education production. In the developing country context, such peer effects are reinforced by more favourable resourcing of elite schools and higher teacher quality that reflect the underfunding of general education and the educational elitism that has prevailed historically.

Understanding the causal effect of attending selective elite schools on student outcomes is not only important for students and parents from a private investment perspective, but also vital for policy makers who need to justify the very existence of the selective school system and the substantial subsidies that favour elite schools in many developing countries. However, identifying the causal effect is empirically challenging due to both ability sorting and heterogeneous preferences which are usually unobservable to researchers (Dale and Krueger 2002, 2014).

The most convincing empirical approach to identify the causal effect of attending elite public schools to date is based on the Regression Discontinuity Design (RDD, or simply RD) exploiting public admission cutoffs in entrance exams. The idea is that marginal students who scored barely above or below the admission cutoff could be regarded as if randomly assigned, such that any differences in outcomes across the two groups can be creditably attributed to attending an elite school. The US evidence suggests very little support for there being a causal effect of exposure to high-achieving, and more homogeneous, peers at elite schools on standardised test scores, college enrolment, graduation, and college quality, for marginal students (Abdulkadiroglu, Angrist and Pathak, 2014; Dobbie and Fryer, 2014). Similarly, Clark (2010) finds only small and statistically insignificant results on the Grade 9 standardised test scores for marginal students attending grammar schools in the UK. However, he finds that grammar school attendance has large effects on taking advanced courses – unsurprising so, since such courses were only available in grammar schools. In contrast, RDD evidence from developing countries indicates a large and often statistically significant effect of attending elite schools – see, for example, Jackson (2010) for Trinidad and Tobago, Pop-Eleches and Urquiloa (2013) for Romania, and Dustan et al (2017) for Mexico.

China has a hybrid and elitist system for the under-funded public school system allowing "school choice with Chinese characteristics" (Wu 2012). Specifically, a dual-channel admission system has been in operation in post-compulsory education since the 1980s, under which the vast majority students are admitted through one of two channels. Admission standards, quotas, and the maximum tuition fees, for both channels, are regulated by the government (Loyalka et al 2014). Under the dominant *standard channel*, which carries only nominal tuition fees (CN¥ 330, or $48.7, per annum in our 2010 sample),[1] applicants to a school are admitted strictly by rank order of the High School Entrance Exam (HSEE) score until the school-specific student quota set by the local education authorities is filled. The *alternative channel*, which accounts for up to one-third of total capacity, admits students who have failed to make the cut for the *standard channel* – but, by paying extra *selection-fees* to their desired school, they are subject to a lower cutoff. In our data period these *selection-fees* were CN¥ 8,000-10,000 (US$ 1182 -1477) p.a. This income is retained by the elite schools who charge them to supplement inadequate government funding (Loyalka et al 2014).

Expressing a willingness to pay (WTP) a fee to attend a specific school in the application process gives the student who can afford the extra tuition fee a lower entry requirement. In the absence of information and preferences for schools, an RDD strategy which explicitly accounts for the *actual* admissions channel might still be biased due to potential selection on unobservable preferences for schools (Dale and Krueger 2002, 2014). Fortunately, we are able to address this potentially important threat to identification by exploiting the administrative school applications database for the population of urban students taking the city-wide HSEE in a cohort, independent of their high school admission outcomes.[2]

We make several important contributions to the literature. Our first main contribution is in the empirical approach which combines cumulative *multi-cutoff* RDD covering all school types with varying selectivity and admission modes across the entire spectrum of the HSEE distribution in a single educational (school district) context, with normalizing-and-pooling RDD analysis that accounts for both eligibility for contextual admission (CA) and declaring a preference for being willing to pay for a *selection-fee* place at a particular cutoff. The novelty

[1] The nominal and PPP exchange rates between the US dollar and Chinese RMB yuan are 6.770 and 3.329 respectively in 2010 (OECD, 2022).

[2] Around 12% of elite public high school places in our sample were allocated to *unregulated-fee* students with HSEE scores below the regulated *selection-fees* cutoff, in return for paying a more substantial unregulated private *selection-fees*. This is a common practice in China for public high schools, especially elite schools, which use the extra revenue generated to top up teachers' salaries and cross-subsidise the *standard channel* students (Dee and Lan 2015).

of the former is in allowing the effect of elite school attendance to vary by the degree of selectivity. Invariably, studies that attempt to account for multi-cutoffs in the Chinese high school admission system use the popular stacked RDD approach (Anderson et al 2016; Hoeskstra et al 2018) which yield a single RD estimate. The latter approach is in the spirit of Dale and Krueger (2002, 2014) where we are effectively only comparing those students who applied to, and were admitted to, the same set of schools, with their counterparts who also applied, but failed to make the relevant cutoffs required. To the best of our knowledge, ours is the first paper that explicitly accounts for school preferences in the complex dual-channel admissions system in China by exploiting the matched administrative records of high school choices of all applicants in the RDD setting. For instance, Hoekstra et al (2018) only footnote the robustness of results to the exclusion of the 10% *selection-fee* students in their main sample. Consistent with Dale and Krueger (2002, 2014), our results show that school preferences matter in identifying the effect of selective high school attendance on standardized test scores.

Secondly, we contribute directly to the relatively thin evidence base on the causal effect of attending academically selective elite high schools on students' academic outcomes, in the context of the world's largest public school system. The system allows for *selection-fees* at the expense of uniform entry standards that would have made for equitable access to highly autonomous and academically selective public elite schools. The weight of existing evidence from developing countries indicates positive causal effects of elite school attendance in general (Jackson 2010; Pop-Eleches and Urquiloa, 2013; Dustan et al 2017) although Lucas and Mbiti, 2014 is an exception in showing no significant effect for elite high schools in Kenya. Our RDD results show robust evidence of heterogeneous effects of attending selective high schools in China that differ by the degree of school selectivity. In contrast to the literature, our estimates range from being indistinguishable from zero at the normal-private and elite-normal schools threshold, to being significantly **negative** at the most selective flagship-elite schools threshold.

Thirdly, our unified empirical setting allows us to reconcile our findings with the existing Chinese evidence based on the RDD approach which tend to focus on a specific type of selective schools or "magnet" classes within elite schools (Ma and Shi, 2014; Dee and Lan, 2015; Zhang, 2016; Anderson et al 2016; Wu et al 2019; and Cannan et al 2022). Hoekstra et al (2018) is arguably the only other study that examines the effect of selective high school attendance across multiple levels of selectivity on standardized test scores in a single Chinese educational context. Apart from the differences in methodological approaches discussed above, our paper also differs in the type of student population coverage and in outcome variables.

Their sample is based on two suburban districts in a rich and populous provincial capital with stronger ability sorting across admission thresholds, within the district (due to *hukou* status), while our sample covers all high school applicants in the whole urban and semi-urban districts who share the same feasible set of high schools in a mid-ranking prefecture. In terms of outcome variables, they focus on the high-stakes College Entrance Exam (CEE) while we can only rely on the High School General Exams (HSGE) due to data limitations. However, in a study using both CEE and outcomes during high school such as the annual city-wide exams, Dee and Lan (2015) show there is a strong consistency of findings.

Our seemingly counter-intuitive significantly **negative** effect of attending a flagship school contrasts with the small positive but statistically significant effect of about 0.07 SD (standard deviation) of attending a flagship (Tier 1) elite high school in China obtained by Hoekstra et al (2018). We show suggestive evidence that the negative effect for marginal students, who barely made into the flagship school, is driven by the very adverse effect for students in the Social Studies track subjects who performed **relatively** badly in HSEE science-related subjects on their High School General Exam (HSGE) scores. This is consistent with the traditional heavy emphasis placed on a science track education in flagship and elite schools. Our finding of the absence of a *negative* flagship effect for applicants who face lower entry requirements (due to eligibility for CA or because of expressing a WTP to pay for selection-fee places), is also consistent with the prevalence of within-school tracking in elite schools where only the top 15% or so students in the HSEE distribution are tracked into high-achieving (magnet) classrooms at the expense of marginal students. In addition, a negative elite school effect might also arise from a possible rank effect that induces weaker students to self-select into the less competitive Social Studies track (a *small fish in a big pond* effect).

The remainder of the paper is organized as follows. Section 2 reviews the relevant literature. Section 3 provides the institutional background for our study. Section 4 introduces the data and presents descriptive analysis. Section 5 outlines the identification strategies based on the classic fuzzy regression discontinuity design (RDD), and how this could be extended to a multi- cutoff setting and/or to accommodate heterogeneous treatment effects using a standard normalizing-and-pooling strategy. Section 6 presents the cumulative multi-cutoffs RDD results of the heterogeneous effects of attending schools with varying degrees of selectivity in a unified setting, i.e. covering all school types in a single educational context. Section 7 shows the cutoff-specific RDDs for each high school application type separately, as well as pooled together following a standard normalizing-and-pooling strategy. Concluding remarks are in Section 8.

2. Literature review

Understanding the effect of attending publicly funded elite schools on students' educational outcomes is an important issue for students and their families, as well as policy makers. However, in the absence of randomised experiments, identifying the causal effect is empirically very challenging, due to the complexity of school systems, and above all, the strong impact of self-selection into different school choices on academic outcomes. A growing number of studies have exploited the RDD approach, an identification strategy that is arguably the closest to the ideal experiment, by exploiting admission cut-offs in entrance exams. The idea is that marginal students who scored barely above or below the publicly announced admission threshold, which is virtually impossible to manipulate, could be regarded as if randomly assigned into the treatment of being admitted to elite schools and the control group of just missing out. Therefore, any differences in school outcomes across the two groups can be creditably attributed to the attendance at elite schools.

By and large, studies from developed countries typically find no significant causal effect. For instance, Abdulkadiroglu, Angrist and Pathak (2014) look at exam schools (selective public schools) in Boston and New York that select students on admissions tests with sharp cut-offs for each school and cohort. They conclude that exam school attendance has little causal effect on test scores or college quality, which they interpret as evidence against effect of peer quality or racial composition on student achievement. Dobbie and Fryer (2014) also use the New York exam schools, but focus on college outcomes which are available for all students rather than just those who attended a public school as in Abdulkadiroglu et al (2014). Using fuzzy RDD, they also find that exposure to high-achieving and more homogeneous peers has, if anything, a negative impact on college enrolment, graduation, or college quality for marginal students. This result is robust to gender, middle school type, and baseline state test scores. Clark (2010) presents evidence for the UK using RDD and Instrumental Variable (IV) estimation. The "East Ridings database" contains grammar school entrance exam scores taken at Grade 5 and the end of compulsory education tests taken at Grade 9 in 1969-1971 for three cohorts of students in this particular school district in the North-East of England (note the minimum school leave age was 15 then). He finds selective school attendance generates only small and statistically insignificant effects on Grade 9 standardised test scores. He also finds, more suggestively, a positive grammar effect on university enrolment – again not surprisingly, since enrolment was largely predicated on performance in those advanced courses.

In contrast, RDD evidence from developing countries tend to suggest significant causal effects. Using administrative data covering all Romanian secondary schools, Pop-Eleches and Urquiloa (2013) present convincing RDD estimates that students who went to more selective schools perform better in high-stakes graduation exams, with the effects often larger and more statistically significant for cut-offs at higher grade levels. Moreover, there is evidence of significant dynamic behavioural responses of students, parents and teachers and equilibrium effects in a setting with ability tracking, using a tailored sample survey. In particular, better qualified teachers are more likely to be matched with higher ability students, both between and within schools, consistent with teaching sorting and ability tracking. Exploiting Mexico City's high school allocation mechanism, Dustan et al (2017) find strong evidence of a trade-off between academic benefit and dropout probability in admission to elite public high schools for marginal students. While admission significantly increases math test scores even using the lower bound estimate, it also raises the risk of dropout partly due to the low transferability between elite and non-elite high schools. Jackson (2010) instruments elite secondary school attendance using discontinuities created by the assignment mechanism for Trinidad and Tobago, accounting for self-selection bias using secondary school preferences. He finds compelling evidence of large positive effect of elite school attendance on secondary school exit exams. Moreover, the beneficial marginal effect of attending schools with brighter peers is higher at high-achievement levels and twice as large for girls than for boys. Lucas and Mbiti (2014) examine Kenya's elite "National" secondary schools using RD where regional quotas led to multiple cut-offs. Despite better peers and resources, the research suggested quite precisely estimated, but statistically insignificant, benefits.

Over the last few years, new RDD evidence has emerged on attending elite (or magnet) public schools in China. Dee and Lan (2015) examine the effect of elite high school attendance on subsequent academic performance in a large city in Inner Mongolia in China between 2006 and 2008. Specifically, they focus on "*selection-fee*" students at elite schools, who scored marginally below the standard-channel admission HSEE cut-offs but pay substantial addition fees on top of the nominal tuition fee payable by students who score above the cut-off. For these *selection-fee* students, they find consistent evidence of no positive effect of elite school attendance on scores in the annual city exam, study track choice, or scores in the high-stakes college entrance exam. However, one important limitation of Dee and Lan (2015) is the inability to account for sorting into the selection-fee option, which involved paying about $3,000 lump-sum fee on top of the $125 annual basic tuition fee. Park et al (2015) use students taking HSEE in 2005 in selected rural counties in Gansu province with per capita GDP at about 49% of the national average, and find elite school attendance significantly increases CEE scores by as much as 0.39 SD. Using students taking HSEE in 2005 in one anonymous suburban district in Beijing, the capital city with per capita GDP 3.3 times the national average, Anderson et al (2016) conclude that attending elite schools have no effect on CEE scores on average. Interestingly, they find statistically significant positive effect of attending more selective **non-elite** schools, at 0.36 SD, which is similar in magnitude to the elite school elite found by Park et al (2015). They reconcile the remarkable differences by highlighting that non-elite schools in Beijing are comparable to elite schools in poor rural areas in terms of school resources and teacher quality, as well as student ability sorting.

Using the population of students starting high schools in 2007 in two suburban districts, with two Tier 1 (flagship) schools each, in one undisclosed densely populated provincial capital in China, Hoekstra et al (2018) show that the only significant positive causal effect of elite school attendance on high school performance occurs from attending flagship schools, driven by the higher concentration of superior-rank teachers rather than peer quality or class size. Specifically, attending the flagship, rather than a Tier 2 elite school, increased CEE scores by just 0.07 SD. However, the effect of attending a more selective flagship school within Tier 1 is indistinguishable from zero. Their use of the high-stakes CEE as the academic outcome is not likely to be important – because they are likely to be highly correlated with the low stakes scores that we use. A more important difference from our setting in this paper is that they choose to restrict the sample to suburban districts because suburban students *must* attend a school in the home district of *hukou* registration, which is likely to result in greater sorting by peer ability across schools than our sample exhibits. Thus, we expect our estimates to be lower for this reason.

Within-school ability tracking is prevalent in Chinese high schools. The top 10-15% of elite school students are placed in "magnet" classes, typically based on the HSEE scores (Ma and Shi, 2014; Hoekstra et al, 2018; and Cannan et al, 2022). Using several cohorts of students taking HSEE in the 2000s in a single urban elite high school in Hebei province, Ma and Shi (2005) find that attending a magnet class increases the gross final exam score at the end of the first semester by 0.65 SD. More recently, using administrative data on three cohorts of students first enrolled in the flagship school between 2015 and 2017 in Qinyang prefecture in Gansu province, Canaan et al (2022) show that students placed into high-achieving classrooms have improved math test scores by a sizeable 0.23 SD, while the effect on Chinese and English are more muted. While placement in high-achieving classrooms has no significant impact on college enrolment as whole, it does significantly increase the CEE scores, which in turn raised the probability of enrolment into elite universities. Moreover, they show that students in high-achieving classrooms enjoy higher-ability peers, smaller class sizes, and better-quality teachers, as well instruction that delves deeper into the curriculum and proceeds at a faster pace.[3]

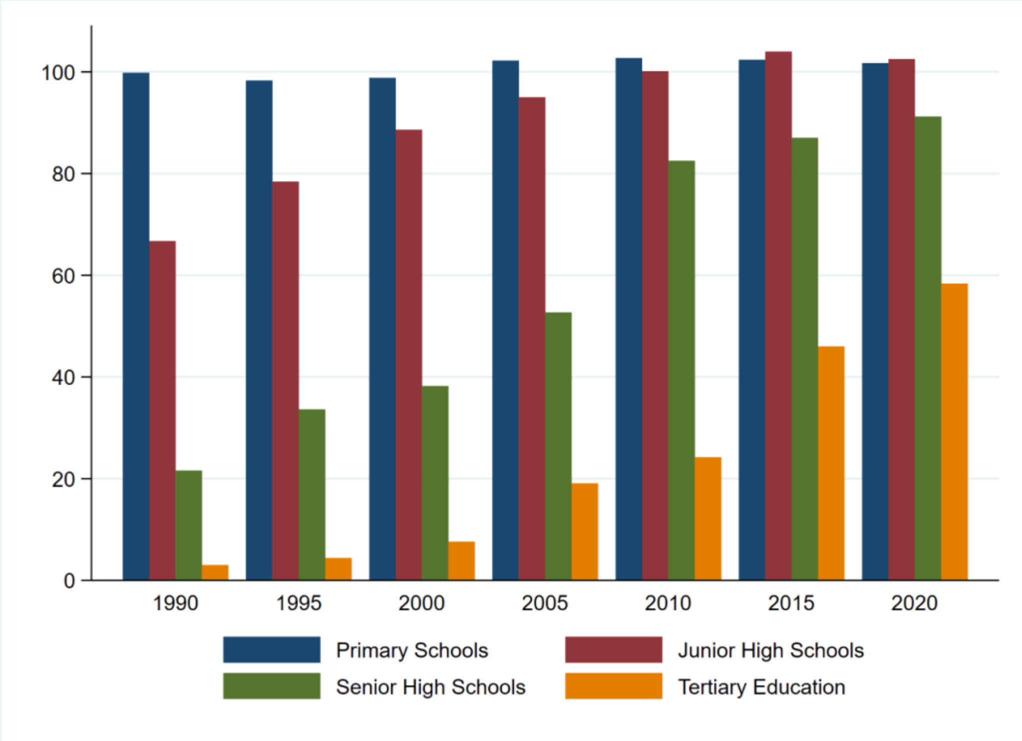
Wu et al (2019) is the only study that examines the effect of both magnet school and magnet school in China. Using students taking HSEE in 2008-2010 in a poor county in Hunan province, they find that enrolment in elite school has small negative, though statistically insignificant on CEE scores, whereas attending a magnet class boosts CEE scores by 0.44 SD. They interpret this contrast as evidence supporting the claim that the potential benefits in test scores from a more selective educational setting, may depend on student ability.

3. Institutional background

Figure 1 shows the trend in gross enrolment ratios for China by education stages, over the period 1990-2020. The year 1986 marked China's formal launch of nationwide 9-year compulsory education, comprising 6 years (age 6-12) of primary schools and 3 years of middle (junior high) schools (age 12-15) in most regions. This was regarded as a very ambitious target at the time in a country with per capita GDP below $300 and a middle school gross enrolment ratio of barely 40% (Tsang, 1986). However, by 2005 the middle school gross enrolment ratio had leapt to 95%; and the proportion of middle school teachers with at least a two-year college qualification surged to 95.2% from a very low base of 27.1% in 1986. The gross enrolment ratio for senior high schools jumped by almost 30 percentage points from 52.7% in 2005, to 82.5% in 2010. This could be partly explained by a spillover effect of the unprecedented higher education (HE) expansion, which increased the annual enrolment of new entrants into regular HE education institutions from 1.08 million in 1998 to 6.08 million in 2008 (Dai et al 2022).

[3] Using three cohorts of middle school applicants in a provincial capital between 2002 and 2004, Zhang (2016) shows that attending elite middle schools has no significant effect on high school entrance exam scores, in RDD estimates based on winning a lottery for oversubscribed schools. Note however, that admission to elite middle schools is not academically selective, due to government regulations for the compulsory education stage.

Figure 1: Gross enrolment ratios (%) of China by education stages, 1990-2020



Data sources: Gross enrolment ratios for primary and tertiary education are from UNSCEO Institute for Statistics (2022). Gross enrolment ratio for middle (junior) and senior high schools are from the National Statistics Bulletin of Education Development (Ministry of Education, various years).

In 2019, China's HE gross participation rate passed the 50% landmark, with 8.20 million new undergraduates (including both the more vocational-oriented colleges lasting 2-3 years and the more selective universities lasting at least 4 years) admitted after taking the CEE. Performance in the city-wide HSEE is the single most important determinant of access to academic high schools (for those aged 15-18 usually), which is the main pathway to HE in China. The HSEE is graded anonymously, with graders kept in isolated residencies cut off from all means of communications from outside. Each grader only grades parts of a test subject. These grading rules make it impossible to manipulate of the HSEE scores around the admission cut-offs based on the total HSEE scores (Dee and Lan 2015).

Despite this phenomenal growth in the number of college graduates, there is little causal evidence of a significant drop in returns to HE, relative to holding a high school qualification alone. However, recent studies have indicated a growing incidence of overeducation among recent graduates, and a widening gap in the HE returns in favour of graduates from the elite universities (Zheng et al 2021).[4]

[4] Elite universities in China typically refer to the *Project 985* and *Project 211* universities, which are the top 100 or so highly selective institutions out of a total of nearly 3000 HE institutions.

The Great HE Expansion, starting in 1999, significantly intensified competition for high school places which were still tightly rationed, through a spillover effect (Dai et al 2021).[5] Using administrative data on over 340,000 students from north-west China who took the CEE from 2001-2010, Loyalka et al (2017) present compelling evidence showing the largest source of unequal college access emerges from the middle to high school transition. Even now, no more than half of middle school graduates are enrolled in academic high schools each year, through competitive selection based on the HSEE scores. Those who do not fare well in the HSEE can only pursue the vocational track of upper secondary education, which does not prepare students for the demanding CEE that are used for selection into university. Consistent with what we see in Figure 1, the probability of high school graduates going to college, becomes increasingly favourable, after 2000, compared to that of proceeding beyond compulsory education.

Due to the heavy tracking and severe rationing of academic high school places, the Chinese post-compulsory education system is highly competitive (Loyalka et al 2015). Like most developing countries, education in China had always suffered from chronic underfunding from public resources. Indeed, government expenditure on education as a share of GDP did not reach the target of 4% until 2012. This was 12 years after the deadline set in the pledge by the central government in 1993.[6] The financial constraint was most severe when the education reform process to restructure the system of both education governance and education management began in 1985. Consistent with the wider reform to transition from central planning to a socialist market economy, the financing of education in China has been substantially decentralized and diversified, to mobilize local public and private resources to help fund basic education (Tsang 1996; Rosen 2004). Evidence on the emergence of a teacher labour market since the mid-1990s suggests that teacher recruitment has also become highly market-oriented and competitive – so as to attract new graduates to teach in secondary schools (Dai et al 2022).

Similar to other developing countries, China promotes a system of academically selective elite public high schools with usually at least one designated *elite* high school in each county or city district (which has the same status). At the prefecture level and above, there are also designated *flagship* public high schools (Loyalka et al 2014). Entry to these flagship high

[5] Studies have shown that returns to academic high schools are low relative to other stages of education in China, consistent with the notion that academic upper secondary education mainly serves as a pathway to HE, resulting in poor returns for those who fail to enroll in colleges.

[6] In 2018, the OECD average share of public spending on education is 4.0% of GDP, with 0.9% spent on tertiary education (OECD, 2021).

schools is very competitive and they are successful in preparing students for the high-stakes CEEs that determine subsequent opportunities for college enrolment.

The cross-subsidies in the dual-channel admissions system has contributed valuable financial resources to support China's extraordinary expansion of education in the post-reform era. However, its impact on equity and intergenerational mobility has been subject to heated debates by the media, researchers, and parents alike. Indeed, academic selection and selection-fees have been banned at the compulsory education stage in recent years. At the high school level, efforts have also been made by the government to moderate the adverse effect of the dual-channel admissions system through: increased fiscal budgets for post-compulsory public high schools; the rotation of teachers across public high schools, as well as tighter regulations on quotas, admission cut-offs, and the maximum amount of selection-fees allowed, among other things.

In terms of our RDD identification strategy, the publicly announced school-specific "*unified enrolment*" cut-offs are crucial. And, while the "*selection-fee*" cut-offs are only tentative, the gap between them and the "*unified enrolment*" cut-offs provide an indication of the degree of competitiveness for places at each school.

4. Data and sample

Our study is based on a novel administrative dataset for the population of high school students enrolled in 2010, in one prefecture in north central China.[7] The prefecture under study (whose identity is withheld under the data access agreement), has a population of well over 2 million in 2019. It is middle ranked in terms of economic development in the country, with a per capita GDP of nearly $9,000 at nominal exchange rate in 2020 current price - only slightly below China's national average of $10,500. The prefecture consists of an urban area and a more rural area, each with its own HSEE. The urban area has a donut shape, with a central district and the immediate suburban district, as well as a semi-urban County Z surrounding it. Students from the four subordinate counties in the prefecture are not part of our urban sample. They take

[7] We focus on the 2010 HSEE exam cohort, for a number of reasons. First, it is the only cohort for which we have the school-specific admission cut-offs for the *selection-fee* mode, in addition to the *unified-enrolment* mode. Second, this is also the only cohort of students directly covered by the administrative records on students, classes, and teachers, as well of expenditures of schools available only from 2012 onwards, when this entry cohort of students are still in the final year of high school. Third, we only have full documentation on the details of the high school application procedures from 2009 onwards.

different HSEEs and generally can only be enrolled into a different set of high schools - except for the flagship school and one of the two elite schools that are open to the whole prefecture.[8]

For 2009, the only year we have full information of HSEE statistics from administrative sources, around 36,500 students were registered for the HSEE across the whole prefecture, of which 5% were repeating middle school graduates. Urban students accounted for 42.0% of all students registered. The total enrolment quota for academic high school education was 16,000, of which 75% were reserved for public schools. In addition, vocational high schools were given a total enrolment quota of just under 8,000, implying that no more than 65.5% of middle school leavers could proceed to the post-compulsory education stage.

The sample used in this paper contains the whole population of high school students from the urban area of the prefecture. We exclude students attending schools outside the designated urban catchment areas, which violated the admissions guidelines.[9] All students in the urban sample share the same feasible set of 18 high schools. Since our focus is on the effect on the attending selective academically oriented high schools, we drop anyone with an HSEE score below 400, which is the official cutoff for public high schools.

Appendix B presents a detailed description of the high school application procedure for our urban cohort. An important advantage of our data is the availability of the high school applications administrative database for the population of urban students taking the city-wide HSEE in the cohort, independent of their high school admission outcomes.[10] This allows us to account for potential school sorting on the basis of preferences which are typically unobserved in RDD studies of school choice.

Our analytical sample, with matched school preferences, consists of 5,239 students after excluding ethnic minority students who account for only 0.4% of urban students.[11] For each student, the data contains scores for the city-wide HSEE (*zhongkao*), as well as the High School General Exam (*huikao,* hereafter the HSGE) taken at the end of the 2nd year (or in the middle of the final year) of high school. Also included are background information of the parents such

[8] Each subordinate county has one elite high school, which admits its "home students" as defined by *hukou* status.

[9] About 3% of urban elite school enrolees attend high schools in two subordinate counties, which lie outside the designated urban areas, implying less than perfect compliance to the official guidelines.

[10] We achieved a perfect match in nearly 97% of the cases, based on the full date-of-birth, gender and full name in Chinese. Of the 3% of cases which have missing application records, 46% can be explained by the *unregulated-fee* admissions route or clearing.

[11] Ethnic minorities are excluded because of small sample sizes and potential eligibility for bonus HSEE points.

as *hukou* and employment status and, importantly, the channel under which the student was admitted. Passing the HSGE at the end of the second year of high school is a prerequisite for proceeding onto the final year of high school, and so is a good proxy for high school completion, regardless of the student's choice of academic track (Loyalka et al 2017). For the majority of students, we have administrative records of the mode of admission, which allows us to distinguish between those paying basic tuition fees from those paying extra "*selection-fees*". For each high school, we also have annual records of numbers of students and classes, per student expenditure, and summary teacher characteristics including credentials and average salaries, etc, from 2012, the year when the 2010 entry cohort was still in the final grade.

Table 1 presents the background information on all high schools which specify the whole urban area of prefecture, including the surrounding County Z, as the catchment. There are a total of 7 public and 11 private high schools. Of the 7 public high schools, 1 is classified as flagship and 2 as elite high schools. As the most prestigious elite school in the entire prefecture, School F stands out as the only school in Tier 1 in the admissions system.

Therefore, the publicly announced threshold for Tier 1 admissions is strategy-proof, in the sense that it is a virtually risk-free choice for everyone, because students are allowed to make up to 13 school-mode choices with two reserved for Tier 1, with the unified-enrolment taking precedence over an optional choice to indicate willingness to pay selection-fee for reduced entry requirement (see Appendix B). All elite and normal public schools, are placed in Tier 2 of the admissions system. While being allowed to enrol students from across the entire prefecture, all private schools are placed in the lower Tier 3. Table A1 in the Appendix show clearly that private schools have far lower entry standard and lower quality teachers.

A detailed description of admission procedure (with the timeline) is presented in the Appendix B.[12] The application procedure is similar to the "Boston Mechanism", and is widely used in many provinces in China (Anderson et al 2016). It is worth noting that F and E1 are open to all students in the entire prefecture, including students in the four subordinate counties outside the urban catchment area. This explains their exceptional sizes, with over 4,400 and 3,700 students spread across three grades (Grades 10-12) in 2012, respectively.

[12] It was emphasized in the 2009 documentation that all admissions must strictly follow the rules and guidelines as set by the national and provincial education authorities regarding student numbers, HSEE requirements, fees charged and deadlines. All new enrolments at academic high schools must be approved by the prefecture-level admissions office.

Table 1: High schools in the 2010 Urban Sample

	School type	Catchment	Admission tier	2012 High-school numbers	2012 High-school Average class size	Superior-rank teachers (%)	Unified enrolment cut-off	Selection-fee cut-off (tentative)	%
Flagship Public High Schools:									
F	Provincial key & provincial exemplary	Prefecture-wide	1	4,488	62.3	32.1	623	606	21.9
Elite Public High Schools:									
E1	Provincial key & provincial exemplary	Prefecture-wide	2	3,717	60.0	27.8	590	544	18.5
E2	Provincial key & provincial exemplary	Urban & County Z	2	2,859	63.5	9.3	587	532	12.0
Normal Public High Schools:									
N1	Provincial exemplary, non-boarding only	Urban & County Z	2	1,330	66.5	28.2	567	526	4.8
N2	Normal	Urban & County Z	2	1,561	55.4	11.9	567	518	7.8
N3	Normal	Urban & County Z	2	1,969	54.7	24.0	550	496	9.5
N4	Normal, non-boarding only	Urban & County Z	2	1,937	64.6	19.0	532	482	8.0
Private High Schools:									
P1-11	Non-elite	Prefecture-wide	3	-	-		-	-	17.5

Note: F, E1, E2 and N4 are dedicated high schools (with Grades 10-12 only). While N1, N2 and N3 also have middle school sections (Grades 7-9), the student numbers and average class sizes in the last two columns only refer to the high school section. N1 and N4 only admit non-boarding students, due to capacity constraints. N3 is unique in targeting children of employees in the state-owned coal mining corporation, who normally attend the affiliated middle school. Superior-rank teachers refer to teachers in the school (including the middle school department if any) with Senior (*gaoji*) or Special-grade (*teji*) – the top rank awarded through rigorous performance evaluations and cannot be earned on the basis of credentials or tenure (Hoekstra et al 2018). Appendix Table A1 presents further detailed school-level descriptive statistics by school type, based on administrative records of the schools in 2012 (when the 2010 HSEE cohort are about to start the final grade of high school).

Applications to high schools in the prefecture are made **after** the city-wide HSEE scores which are taken at the end of Grade 9 (the final year of middle school), are known. Students who intend to continue their education beyond the compulsory education stage, list up to 13 school choices in total, on the application form. While the strategy-proof nature of the school choices allows us to treat the preference ranking as exogenous when modelling the selection of students by schools being able to account for preferences makes a difference to our estimates.[13] In the following analysis, we will label F as the **flagship school** and label E1 and E2 as **elite schools**, respectively. Corresponding to the distinction between the alternative and the standard channel under the dual-channel admissions system (Loyalka et al 2014), the so-called "*selection-fee*" option for a specific school is regarded as a separate choice from the so-called "*unified or contextual admissions (CA) enrolment*" route, for the same school. A centralised and computerized admission system then proceeds sequentially, by the tier of the schools. Each (public) school is given a strict quota on the maximum number of students it can admit.

The publicly announced school-specific admission cut-offs then mandate the minimum total HSEE scores required of the student to be admitted through the standard channel, thus only subject to basic tuition fees. Within each admission tier, schools select students in turn according to the order of school preferences in the application form. Oversubscribed schools enrol students in descending order of the students HSEE scores. Students who are not yet admitted then are considered by their next preferred school. And so on.

If the student fails to get any offer from all preferred schools in one tier, the application will then be passed on to her preferred schools in the next tier. After the conclusion of the main round of admissions, there is a further clearing round for schools which have not filled up their quotas. It is also worth noting that N2 has an identical "*unified-enrolment*" cut-off as N1, a provincial exemplary school. It is quite plausible that the lack of boarding option might be a factor in explaining N1's lowest student share among all public schools in our urban sample.

[13] CA was only introduced in 2009, the year before our cohort took the HSEE. Since CA eligibility requires the applicant to stay with the same middle school for the whole 3 years, no one should be able to exploit CA by moving to different middle schools. Moreover, neighbourhood sorting is probably not a big issue in our context, as the most popular middle schools are excluded from the CA scheme. A further worry is that some students might be precluded from some choices by geography. High Schools are in the CBD while many students come from semi-rural locations. However, the system is well adapted to providing room and board for out-of-town students. High school boarding is inexpensive, although the conditions are rather basic. Students live in large dormitories shared by 6 or more students. There is a lot of structured and supervised studies and lots of exercises to complete in school (taking up most of the time). Discipline is strictly enforced, and bad behaviour is not tolerated by elite schools. In general, Chinese parents value children's education highly, due to Confucius values and social norms. This even applies to the lower SES families to a large extent.

Figure 2 shows the geographical location of all high schools and middle schools in our urban sample. Virtually all high schools are located in the urban centre (denoted CBD) in the map. Table 2 shows the sample distribution by admission modes, for public and private schools separately. In the former category, we can also distinguish between flagship, elite and normal schools. Only the *unified-enrolment*" and *CA* modes can be characterised as standard channel admissions based on academic merit.

Figure 2: Geographical location of high schools and middle schools by school type

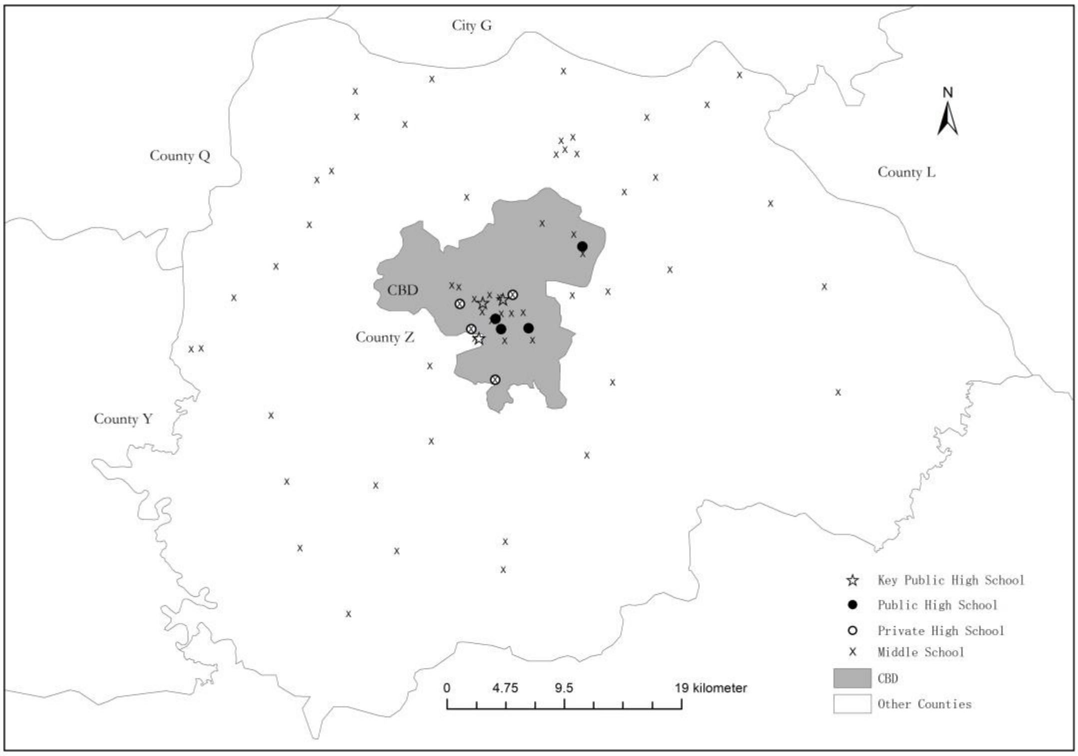


Table 2: Distribution of admission mode (%), by high school type

	Public Schools by Type			All Public Schools	All Private Schools	All Schools
	Flagship School	Elite Schools	Normal Public Schools			
	(1)	(2)	(3)	(4)	(5)	(6)
Standard Channel:						
Unified-enrolment	57.6	68.7	83.6		93.3	75.3
Contextual Admission (CA)	11.2	5.7	-		-	4.2
Alternative Channel:						
Regulated selection-fee	19.0	13.8	10.7	14.1	4.7	12.5
Unregulated fee	12.2	11.8	5.7	9.7	2.1	8.3
Total	100.0	100.0	100.0	100.0	100.0	100.0
Observations	1,148	1,597	1,576	4,321	918	5,239

The so-called "*unified enrolment*" entry, accounting for 71.2.% and 93.3% of public and private school students in the sample respectively, entitles the student to basic tuition fee status according to the HSEE performance, at only CN¥330 per annum. The CA mode was first introduced in 2009, and expanded in subsequent years, to allow top graduates from underrepresented middle schools, who scored marginally below the HSEE cut-off, to enjoy basic-tuition entry to flagship and elite public high schools nonetheless. Similar to the contextual admissions educational policies in the US and elsewhere, this was an important equity-enhancing policy initiative, keenly promoted by the government in recent years. While the regulated alternative channel of the "*selection-fee*" mode accounts for less than 5% of private school students in the sample, it accounts for 10.7% of normal public school places, rising up to 13.8% and 19.0% for elite and flagship schools respectively. In 2010, *selection-fee* cost CN¥10000 and CN¥8000 on top of the basic tuition fees per annum at the flagship and elite schools, respectively. The residual category of *unregulated-fee* refers to an alternative channel, that captures students where admission mode is missing.[14] These entrants are typically students with HSEE scores well below the official "*selection-fee*" cut-offs, and are charged much higher fees by the elite schools, which keep this supplementary fee income to supplement their teachers' salaries, otherwise subject to public sector pay scales (Dee and Lan 2015).

Figure 3 shows the standardised HSEE and HSGE scores by entry mode, for flagship and elite schools only. As expected, the flagship school has significantly higher scores in both HSEE and HSGE than elite schools. Regardless of the school type, *unified-enrolment* entry students perform better than the *CA* entry students in HSEE, but only marginally so at the flagship school. On the other hand, *selection-fee* entry students' HSEE scores are significantly below those of their basic-tuition peers, by at least 0.15 SDs regardless of school type. Finally, students enrolled through *unregulated-fee* channels have by far the lowest HSEE scores, even below the mean of all HSEE takers. Students admitted through the unregulated channel are likely to pay substantially more than the regulated *selection-fees*, with the excess fees positively related to the deficit to the official cut-offs (Dee and Lan, 2015). The standardised HSGE scores also display a very similar pattern, with a substantial gap between standard channel students paying basic tuition fees and alternative channel students paying extra fees.

[14] In the setting of Dee and Lan (2015) which is fairly similar to ours, the *unregulated-fee* ranged from $6000 to $10000, well above the $3000 regulated "*selection-fee*", with the exact amount determined by the bargaining power of the student's parents.

Importantly, Figure 3 suggests that the value added of attending elite schools, as measured by the difference between standardised HSEE and HSGE scores, varies by selectivity as proxied by school type. At the flagship school, there appears to be a robust negative HSEE gradient regardless of the admission mode. In contrast, there is no evidence of a consistent negative gradient for elite schools, for all except for the *unregulated-fee* admission modes. This pattern justifies our distinction between the flagship and elite schools in the formal analysis.

Figure 3: Standardised HSEE and HSGE scores by entry mode, flagship vs elite schools

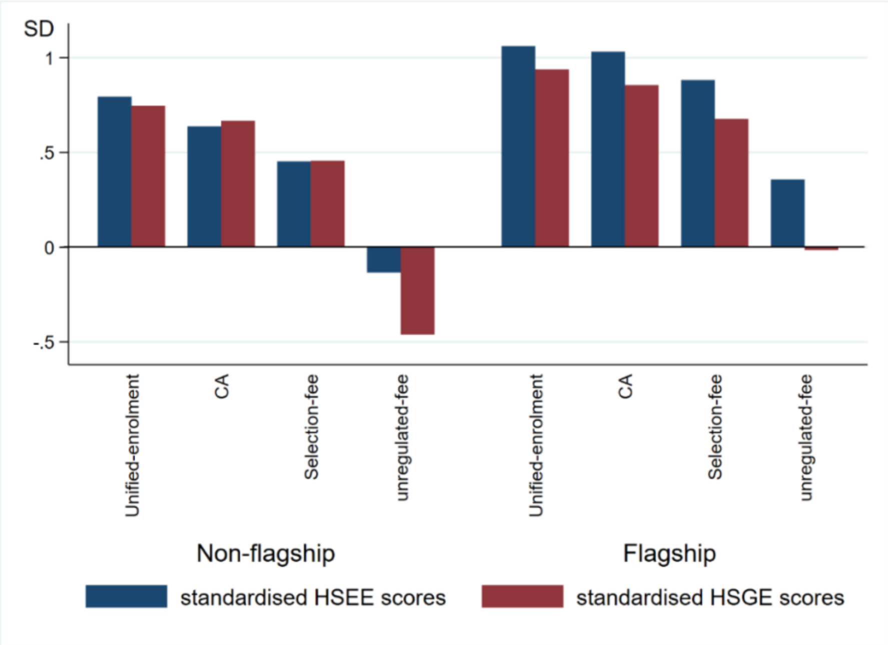


Table 3 presents summary statistics for the urban sample, by school status. Of all 5,239 urban students with HSEE scores of at least 400 starting high school in 2010, 2,745 (or 52.4%) were enrolled in a flagship or elite school, all publicly owned. For the remaining students, enrolled in non-elite high schools, 36.8% attended a private high school. The maximum attainable HSEE total score in 2010 is 690 points, consisting of 120 each for Chinese, Maths and English (including 20 points for listening comprehension), 150 for Comprehensive Science, 100 points History and Society, 50 for Moral Ethics and 30 for Physical Education.[15] The gap in the (adjusted) HSEE total scores between flagship/elite schools and their less selective counterparts is 67.7 points.[16] This corresponds to a gap in the standardised HSEE total scores

[15] To be eligible for elite schools, students must also obtain a minimum pass mark of 30 points out of 50 in Laboratory Abilities, which is not included in the total HSEE score.

[16] Only 0.8% of students in the sample received 5 or 10 bonus points on top of their raw total HSEE score, for specific honours such as provincial-level model student or student leader. Moreover, 1.6% of students and 1.2%, respectively, received special considerations for being the best students in their middle school or have some

of 0.664 standard deviations (SDs) in favour of the former. The HSEE scores of 18.1% of flagship and elite school students were above the admission cut-offs (623 in total score) for the flagship school, compared to 0% of attendees at non-elite schools. Another 49.6% of elite school students have total scores below 623 but above 587, the cut-off for E2, which we term the "elite school" cut-off. Interestingly, 4.6% of non-elite school attendees are found in this HSEE score band. This might be because they were not offered a place at their preferred elite school and/or they chose a non-elite school due to characteristics such as proximity to home.

Table 3: Means by school status

	Flagship or Elite Schools	Other Schools	Difference
School characteristics:			
Private (*minban*) school	0.000	0.368	-0.368***
Private school outside urban area	0.000	0.039	-0.039***
Flagship school (F)	0.418	-	0.418***
Elite schools (E1 & E2)	0.582	-	0.582***
(Adjusted total) HSEE (*zhongkao*) score			
Standardised total score	0.758	0.094	0.664***
HSEE Total score	586.1	518.4	67.7***
>=623: above flagship *unified-enrolment* cut-off	0.181	0.000	0.181***
587-622: Between F and E2 *unified-enrolment* cut-offs	0.496	0.046	0.450***
532-586: between E2 *unified-enrolment & selection-fee* cut-offs	0.200	0.470	-0.269***
400-531: between E2 *selection-fee* & normal public high school cut-offs	0.122	0.484	-.295***
Standardised HSGE (*huikao*) scores			
Raw total scores	483.0	427.4	55.6***
Standardised total scores	0.645	0.014	0.630***
Student characteristics:			
Age	15.79	16.02	-0.233***
Boy	0.459	0.446	0.013
Parental characteristics:			
Father unemployed/redundant/retired	0.037	0.019	0.018***
Father agricultural *hukou*	0.323	0.454	-0.131***
Father non-agricultural *hukou*	0.506	0.286	0.220***
Father status missing	0.134	0.240	-0.106***
Father CCP/Political Party member	0.251	0.105	0.146***
Mother unemployed/redundant/retired	0.057	0.030	0.027***
Mother agricultural *hukou*	0.362	0.478	-0.116***
Mother non-agricultural *hukou*	0.381	0.144	0.237***
Mother status missing	0.200	0.348	-0.148***
Mother CCP/Political Party member	0.063	0.018	0.045***
Observations	2,745	2,494	-
Share of sample (%)	52.4.11	47.6	-

Note: ***, ** and * indicate statistical significance at 1%, 5% and 10% respectively.

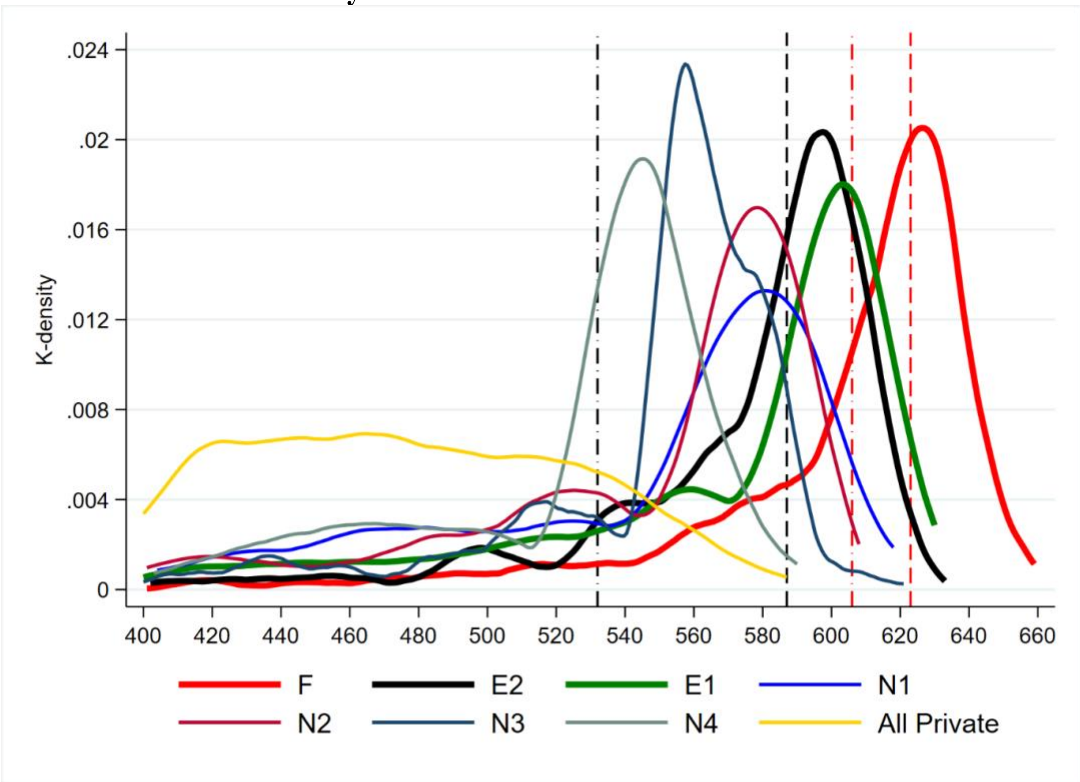
provincial-level talents in arts or sports. The, albeit small, art and sport talent category can get up to 50% discount from the admission cut-offs for *unified-enrolment*.

Furthermore, 20.0% of flagship or elite school attendees and 47.0% of non-elite school attendees respectively, have HSEE scores below 587 but above 532, the *selection-fee* cut-off for E2. Students in the latter group could have been enrolled to elite schools, in principle, if they had chosen the *selection-fee* option at a specific elite school in their applications (and paid for the privilege). Indeed, the 26.9% gap in favour of non-elite school attendees in this HSEE score band is highly statistically significant. In total, 32.2% of all elite school attendees failed to achieve the elite school cut-off for *unified-enrolment*, consistent with a significant minority of elite school places been allocated based on criteria other than HSEE scores alone, through the *CA*, *selection-fee* or *unregulated-fee* channels. Flagship and elite school students are on average 0.23 years younger than their non-elite counterparts but are almost equally likely to be male. Moreover, there are notable differences in parental characteristics between school types. Flagship and elite school students are much more likely to have parents (of either gender) with a non-agricultural *hukou*, or Chinese Communist Party, or other political party memberships - that proxy for high social and cultural capital in Chinese society. Somewhat surprisingly, the incidence of being unemployed, redundant, or retired, for either parent, are higher for elite school students. One possible explanation is that effect of retirement on elite school attendance is ambiguous, in contrast to the other two states.

Figure 4 shows the distribution of the standardised HSEE scores for the 7 public high schools individually and all private schools grouped as a whole. The flagship school, F (red), is clearly the most selective as measured by the entry scores. The two elite schools, E1 (green) and E2 (black), almost overlap each other. N1 (blue) turns out to have significantly lower mean and more dispersed distribution of HSEE scores than all elite schools. Consistent with the same admission cut-offs reported in Table 1, the distribution for N2 is very similar to that for N1. This graph lends strong support to the use of the publicly announced admission cut-offs (dashed verticals)) for *unified enrolment* entry to F (623) and (dotted verticals) E2 (587), as the relevant cut-offs for enrolment to the flagship and elite schools, respectively.

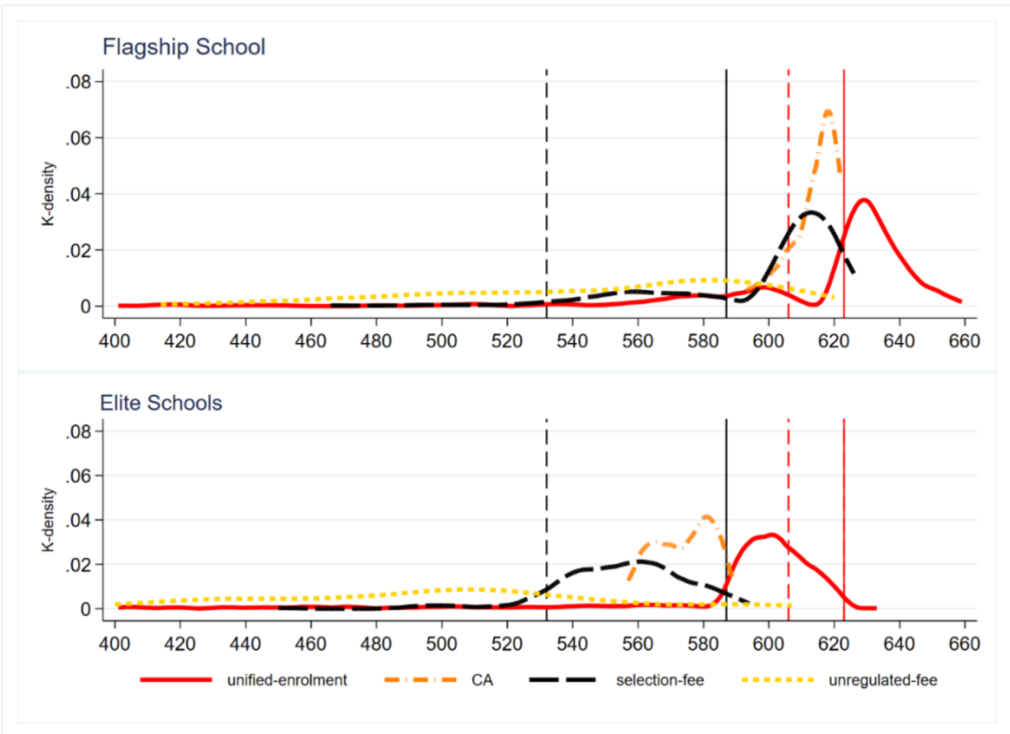
The upper and lower panel of Figure 5 focus on the standardised HSEE scores distribution by admission mode, for the flagship and elite schools respectively, to disentangle any composition effect. The patterns are very similar, with basic-fee paying students admitted through *unified-enrolment* having significantly higher entry scores than *selection-fee* students. The *CA* mode students only dominate the *selection-fee* mode students at the elite schools. The residual "*unregulated-fee*" entry students have by far the lowest and the most dispersed entry scores for both tiers of elite schools.

Figure 4: Raw HSEE scores by school



Note: Vertical lines indicate the HSEE admission cut-offs at 623 (F), 587 (E2) and 567 (N1) points. HSEE total score is truncated at 400, the official threshold for public high schools.

Figure 5: HSEE scores distribution by admission mode, flagship and elite schools



Note: Elite schools include E1 and E2. Solid and dashed red vertical lines indicate the *unified-enrolment* and *selection-fee* cut-offs at 623 and 606 respectively for the flagship school. Solid and dashed black vertical lines indicate the *unified-enrolment* and *selection-fee* cut-offs at 587 and 532 respectively for elite schools. HSEE total scores are truncated at 400, which is the official threshold for normal public high schools.

5. Identification strategies

Compared to other quasi-experimental methods such as differences-in-difference (DD) or Instrumental Variables (IV), the regression discontinuity design (RDD) has several desirable properties including simplicity, transparency, and objectiveness (Hahn et al 2001; Lee and Lemieux 2010; Villamizar-Villegas et al 2021). It is easy to falsify and straightforward to interpret. Moreover, RDD requires very little information for identification when there is an explicit design for the treatment mechanism, and can be viewed as a localized randomised trial (see e.g. Cattaneo et al 2020a). The disadvantage is that the estimates can only be interpreted as treatment effects for marginal students.

For student i, we standardise the adjusted HSEE score S_i around the k^{th} (k=1,2,3) most selective elite school type, using the *unified-enrolment* admissions threshold $\underline{S_k}$:

$$S_{ik} = \frac{HSEE_i - S_k}{Standard\ Deviation\ of\ HSEE_i} \quad k = 1,2,3 \tag{1}$$

In this paper, we investigate the effects of attending high schools with diminishing degrees of selectivity, from "flagship", "elite", through "normal", and thence to "private" schools. S_1(=623), S_2 (=587) and S_3 (=523) hence correspond to the *unified-enrolment* admission cut-offs for F, E2 and N4 in Table 1, respectively. Note that the corresponding *unified-enrolment* admission cutoff for E1 is 590, virtually indistinguishable above that for S_2 while that the least selective normal school N4 is significantly below other normal schools. The gap between S_1 and S_2 is approximately 0.35 SD ,while that between S_2 and S_3 is about 0.63 SD.[17]

The outcome variable as measured by the standardised HSGE score for student i around the selective school type k admission cut-offs can be modelled as

$$HSGE_{ik} = \beta_k T_{ik} + \gamma_k Z_{ik} + e_{ik} \quad \text{where } T_{ik} = \boldsymbol{I}(S_{ik} \geq S_k) \tag{2}$$

where T_{ik} denotes the treatment status which takes the value of 1 for attending elite school type k and 0 otherwise, the vector $\boldsymbol{Z_{ik}}$ denotes exogenous (or "pre-intervention") covariates, and e_{ik} is the error term. The standardised HSEE score S_{ik}, re-centred around the relevant admission cut-offs S_k, is the *running variable* which determines the treatment status in a fuzzy manner.

This standard fuzzy RDD set up identifies the average treatment effect of attending elite school type k on standardised HSGE scores around the relevant admission threshold. To the

[17] Since all sample members were from the same middle school graduation cohort, there is no time variation.

extent that the standardised HSEE scores around the publicly announced admission cut-offs are as if randomly assigned, the fuzzy RDD estimates can be interpreted as the value-added of attending elite school type *k*, for students who had barely scored above the required HSEE cutoff relative to those who had barely missed out.

The unique setting of the Chinese education system implies significant barriers to a straightforward application of the fuzzy RDD strategy. In this paper, we first present, in Section 6, a cumulative multiple-cutoffs RDD analysis under a unified setting which highlights the heterogeneity in the effects of attending academic high schools with increased degrees of selectivity. This is followed up by the cutoff-specific RDD analyses in Section 7 for each high school application type separately, as well as pooled together following the standard normalizing-and-pooling strategy.

While the newly developed multiple cutoff RDD framework is still unable to deal with heterogeneous treatment effects (see Cattaneo et al 2020b), it offers the framework needed to undertake multiple cutoff RDD analysis within a unified setting. This is particularly attractive in our context, as we are interested in the potentially highly heterogenous treatment effects with increasing degrees of selectivity across four different types of academic high schools, i.e. at the cutoffs for normal public schools vs private schools, elite vs normal public schools, and flagship vs elite schools respectively. Whereas the multi-cutoff RDD analysis overlooks the heterogeneity in application types, we present the cutoff-specific RDD analyses in Section 7 for each high school application type, as proxied by the eligibility for CA and the WTP for the opportunities to attend more selective schools, separately as well as pooled together, following the well-developed normalizing-and-pooling strategy (Cattaneo et al 2016).

6. Multiple Cutoff RDD Analysis

We exclude from the RDD analysis any students who were admitted through the unregulated *selection-fee* channel, who account for only 8.3% of students who scored at least 400 HSEE points described in Table 3, and merely 3% of the subsample with HSEE score points of at least 567 to be used for the flagship-elite school cutoff later. By definition, we do not know the admission cutoffs set by individual schools for these unregulated students. Moreover, among these students the monotonicity assumption required for the RDD analysis could be breached, when students with lower HSEE scores outbid their counterparts with higher scores by paying unobservable higher unregulated *selection-fees* to schools.

Empirically, we start by applying the cumulative multi-cutoff (three in our case) RDD (Cattaneo et al 2016; Cattaneo et al 2020b) for normal-private, elite-normal, and flagship-elite schools respectively, and provide robust bias-corrected inferences for pooled and cutoff-specific RD treatment effects in a unified setting. We use the data-driven bandwidth selector following Calonico, Cattaneo & Titiunik (2014a, 2014b) and report robust p-values throughout. Note that the validity of this approach relies on quite restrictive assumptions (Cattaneo et al 2016).

Table 4 presents the multi-cutoff RDD estimates at the 3 cutoffs, which are treated as cumulative as different school types could be regarded as somewhat different due to the different degrees of selectivity (Cattaneo et al 2020).[18] Under this parsimonious specification with no covariates, the cutoffs are simply based on the (lowest) pre-announced dominant *unified-enrolment* admissions thresholds which dominate each school type. Thus, this overlooks potential heterogenous treatment effects arising from different application types. For students who barely scored the HSEE cutoffs required for *unified-enrolment*, the RDD estimates indicates significant and positive effects on attending the more selective school types, by 35 and 42 percentage points for the normal-private and flagship-elite cutoffs respectively. On the other hand, crossing the HSEE threshold for the elite-normal cutoff has a more moderate 13 percentage point effect, which is statistically insignificant at conventional levels.

Table 4: Multiple Cutoff RDD estimates

	Normal vs Private	***Elite vs Normal***	***Flagship vs Elite***
Running variable (HSEE):			
Cutoff	532	587	623
Range	400-560	561-605	606-659
Attend more selective schools (1st stage)	0.348	0.134	0.420
P (Robust bias-corrected)	0.002***	0.261	0.000***
Bandwidth estimate (left / right of cut-off)	39.02/14.86	11.41/5.65	7.78/11.61
Effective # of Observations	800	639	538
Standardised HSGE score (2nd stage)	-0.165	0.049	-0.284
P (Robust bias-corrected)	0.114	0.418	0.005***
Bandwidth estimate (left / right of cut-off)	34.00/18.64	17.48/11.06	10.08/11.19
Effective # of Observations	841	1,106	538

Note: ***,**, and * indicate statistical significance at the 1%, 5% and 10% levels respectively. N=4,802. No covariates are included.

[18] We use non-overlapping ranges of the HSEE scores for each cutoff, with end points determined by the middle points between adjacent cumulative ordered cutoffs, and the Local Linear RD point estimator, as recommended by Cattaneo et al (2020b, p 870).

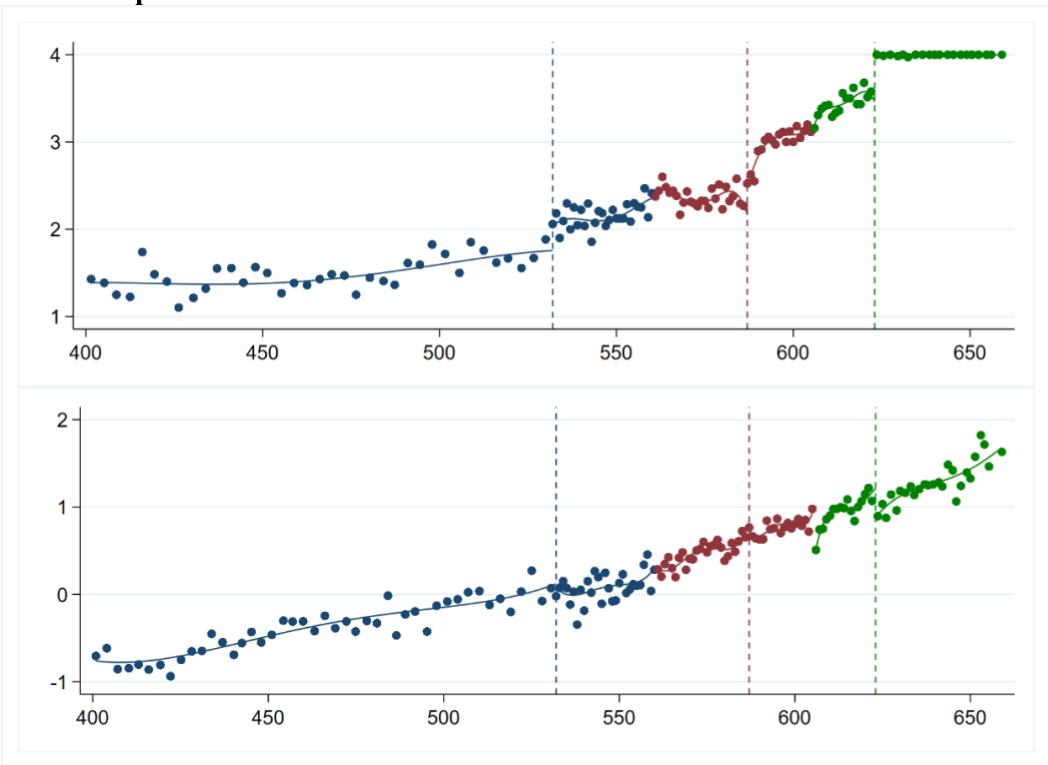
Importantly, the RDD effect of attending more selective high schools on the standard HSGE scores are statistically insignificant for the first two cutoffs, suggesting a zero value-added effect of attending normal or elite schools for marginal students, conditional on HSEE scores. What is particularly striking in Table 4 is the substantial **negative** value-added effect of attending the flagship school vs elite schools, at -0.28 SD, which is statistically significant at the 1% level.

Figure 6 visualizes Table 4, by plotting the school type in the upper panel, and the standardized HSGE scores in the bottom panel, against the running variable HSEE scores. Consistent with the table above, the upper panel shows strong positive discontinuities in school attendance, at both the normal-private and the flagship-elite thresholds. In contrast, there appears to be no visible discontinuity at the elite-normal margin. In the bottom panel of Figure 6, there *is* a large negative discontinuity in HSGE scores - but it is only visible within a very narrow window around the flagship-elite threshold.

Figure 7 highlights the RDD treatment effects across the cutoffs, by order of polynomial for the RD estimator. The top left panel corresponds to Table 4 and Figure 6, which are based on the Local Linear RD point estimator (p=1). Increasing the order of polynomial to p=2 in the top right makes little difference to either the point estimates or the statistical significance of the results. When the order of polynomial is raised further to p=3, the negative effect of attending flagship on HSGE scores is no longer statistically significant.

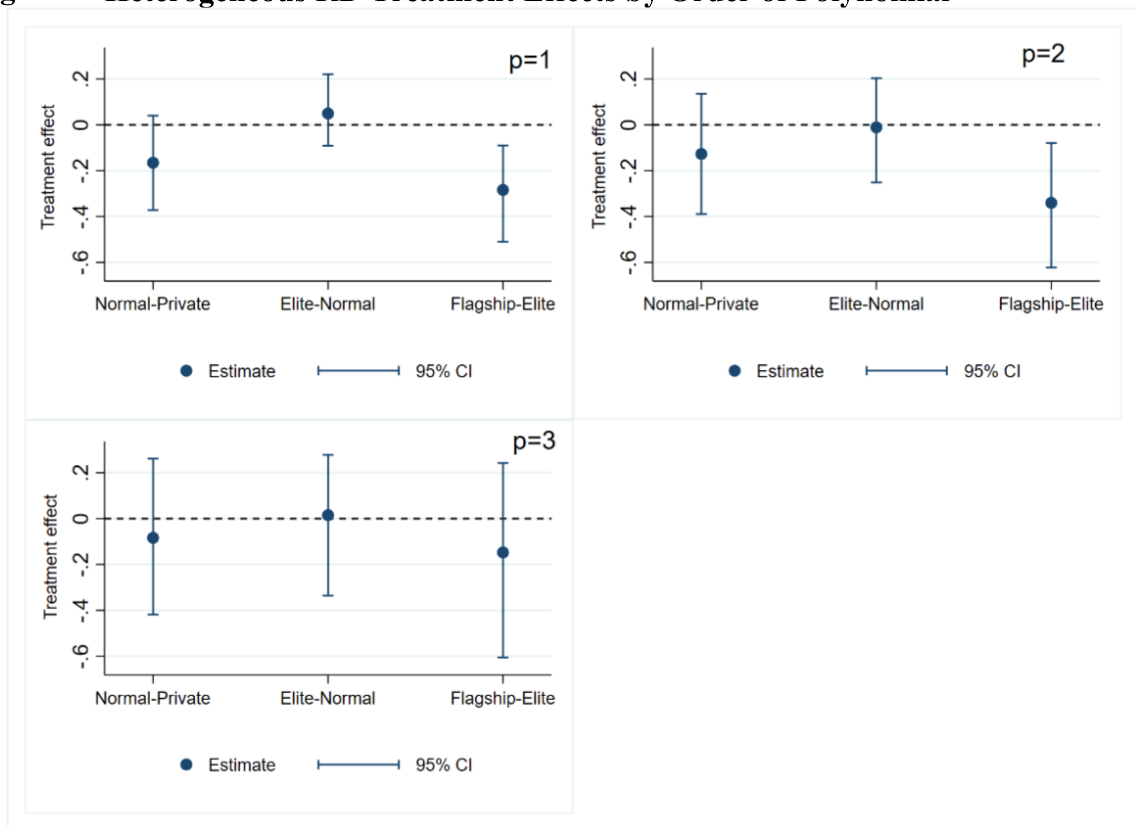
This is consistent with Gelman and Imbens (2019) compelling evidence that suggests that the use of polynomials beyond quadratic causes noisy point estimates, over-sensitivity, and poor coverage of confidence intervals. Under the cumulative multi-cutoff RDD setup, the only statistically significant effect is the **negative** effect at the flagship-elite school threshold, for marginal students who are only barely above and below the cutoff. We investigate this in more detail below.

Figure 6: Multiple Cutoff RDDs



Note: The upper panel shows the discontinuity in attending more selective school types at various cutoffs in the HSEE running variable, with 1, 2, 3, and 4 on the vertical axis representing private, normal, elite and flagship schools respectively. The bottom panel shows the corresponding effect of attending different school types on the standardized HSGE scores. The observations represented by the green, red and blue dots are used for fuzzy RDD estimation at the flagship-elite, elite-normal and normal-private thresholds, respectively.

Figure 7: Heterogeneous RD Treatment Effects by Order of Polynomial



7. Cutoff-specific RDD Analysis

7.1. Main results

In this section we focus on cutoff-specific RDDs, pooling across application types following the standard normalizing-and-pooling strategy. We focus on the flagship-elite school cutoff, which was negative and the only significant in the multiple cutoff setting. We leave results for the elite-normal and normal-private school cutoffs, which are consistent with the multiple-cutoffs RDD results above, to the Appendix Table A3.

From an econometric perspective, conditioning on the **observed** *selection-fee* and contextual admissions status is problematic, as they are likely to violate the key Stable Unit Treatment Value Assumption (SUTVA) which rules out interference between treatment units (Cattaneo et al 2016). For instance, scoring above the HSEE cutoff for the standard-channel precludes admissions through the *selection-fee* mode, independently of the willingness to pay indicated in the school applications.

To address this problem, we will estimate application-type-specific RDD separately and pooled, at the relevant cutoffs for each school type. The intuition is that application types in terms of each applicant's CA eligibility and willingness to pay *selection-fees* for lower entry requirements at the school applications stage are **predetermined** from the perspective of the admission cutoffs set by the local education authorities only after the whole distribution of HSEE scores are known. Therefore, within each type of applications, everyone has similar school preference such that a comparison of students barely above and barely below the HSEE admissions cutoff set by the local education authorities can recover the true causal treatment effect of attending a more selective school (Dale and Krueger 2002, 2014; Cattaneo et al 2016). To the extent that conditioning on application types mitigates potential violations of SUTVA, subsample fuzzy RDDs are unlikely to be biased arising from spillover effects. Finally, the type-specific RDD estimates are pooled across all application types, to derive the efficient pooled RDD estimate for attending the relevant academically selective school type S_k (k=1,2,3).

As described in the Appendix B, flagship school F is the only Tier 1 school in the whole prefecture in the high school application form, and effectively a strategy-proof free choice for anyone who considers oneself as having a realistic chance of scoring above the *unified-enrolment* flagship cutoff. Indeed, *unified-enrolment* takes precedence over *selection-fee* in the admission procedure, such that there was no risk of having to pay the substantial *selection-fee* had the student crossed the higher *unified-enrolment* cutoff. This design also makes the willingness to pay for flagship school in the high school applications strategy-proof, which only depends on the how much the family values flagship over elite schools and family's credit constraint, but independent of other students' preferences.

We start with 2,641 applicants with HSEE scores at 567 or above (admitted through one of the regulated admissions channel), which guarantees a *unified-enrolment* place at the most selective normal school (N1 and N2 in Table 2). Note this range allows sufficient common support for the flagship *selection-fee* cutoff (606) and the contextual admissions cutoff (593). We further exclude 7.6% of applicants who did not apply for the flagship school through any of the four routes (namely talent, contextual-admissions, *unified-enrolment* and selection-fee) and the 1.7% of applicants who applied for the talent route which might give them substantial discounts in HSEE score requirement. The resulting sample of 2,397 flagship school applicants to be used in the RDD has a mean HSEE score of 603.6, and a realized probability of flagship and elite school admissions of 37.5% and 42.1% respectively.[19]

The school preferences which are typically unobservable in RDD studies of school choice can be fully characterized in our case by the applicants' eligibility for the contextual admissions route which is determined by the middle school attended and the middle school teacher assessments and exams, as well as the willingness to pay for the *selection-fee* route places. The former gives HSEE discounts of up to 30 score points relative to the *unified-enrolment*, at 593 instead of 623. However, the discontinuity is very fuzzy as admissions depend on both middle-school-specific and overall quotas allocated for contextual admissions.[20] The latter route only gives a modest discount of 17 score points, possibly driven by excess demand for the flagship school compared to the two elite schools which allow *selection-fee* discounts of 46 and 55 score points respectively. Whereas CA eligibility reflects neighbourhood sorting (as primary and middle schools are restricted to enrolling their catchment areas students) as well as the student's performance in the middle school; willingness to pay *selection-fees*, on the other hand, is more directly related to parental credit constraints and general parental preferences for education.

Figure 8 compares the mean standardized HSEE and HSGE scores, as well as the high school admissions outcomes by the 4 application types. For those not eligible for contextual admissions, there is no visible difference in the mean HSEE scores, but willingness to pay

[19] The non-applicants and the talent-mode applicants have mean HSEE scores of 582.0 and 600.2, respectively. This suggests that non-application is driven by very low subjective probability of flagship school admissions.

[20] Table 5 shows that almost 1300 applicants, accounting for 52% of all flagship school applicants, are eligible for CA, which is 8 times the total quota allocated to this route. Moreover, we do not have the middle-school-specific quotas that would be needed to obtain more precise estimates.

increases the chance of flagship admission by over 3-fold. Even for applicants eligible for contextual admissions, willingness to pay boosts flagship admissions by nearly two-fold. On the other hand, contextual admissions eligibility increases the chance of flagship admission by about 100% for applicants unwilling to pay and by about 30% for those willing to pay. Figure 8 also indicates that school preferences clearly matter for high school admissions and potentially educational outcomes, even conditional on the HSEE scores. This implies that overlooking the typically unobserved effect of school preferences on school choice, which is common in most RDD studies, are likely to result in biased pooled estimates of the causal effect of attending more selective schools in empirical research.

Taking advantage of the full applications records in our data we next explore, in Table 5, the heterogeneity of treatment effects by application types, separately and pooled, following the normalizing-and-pooling strategy (Cattaneo et al 2016) that is now well-established in the literature. We control for exogenous (pre-treatment) covariates throughout, to improve the precision of the RDD estimates. As the cutoff of 606 points for WTP the selection-fee is non-binding if the applicant is also eligible for contextual admissions, we have 3 instead of 4 application types effectively.

Figure 8: Standardized HSEE/HSGE scores and admission, by application type

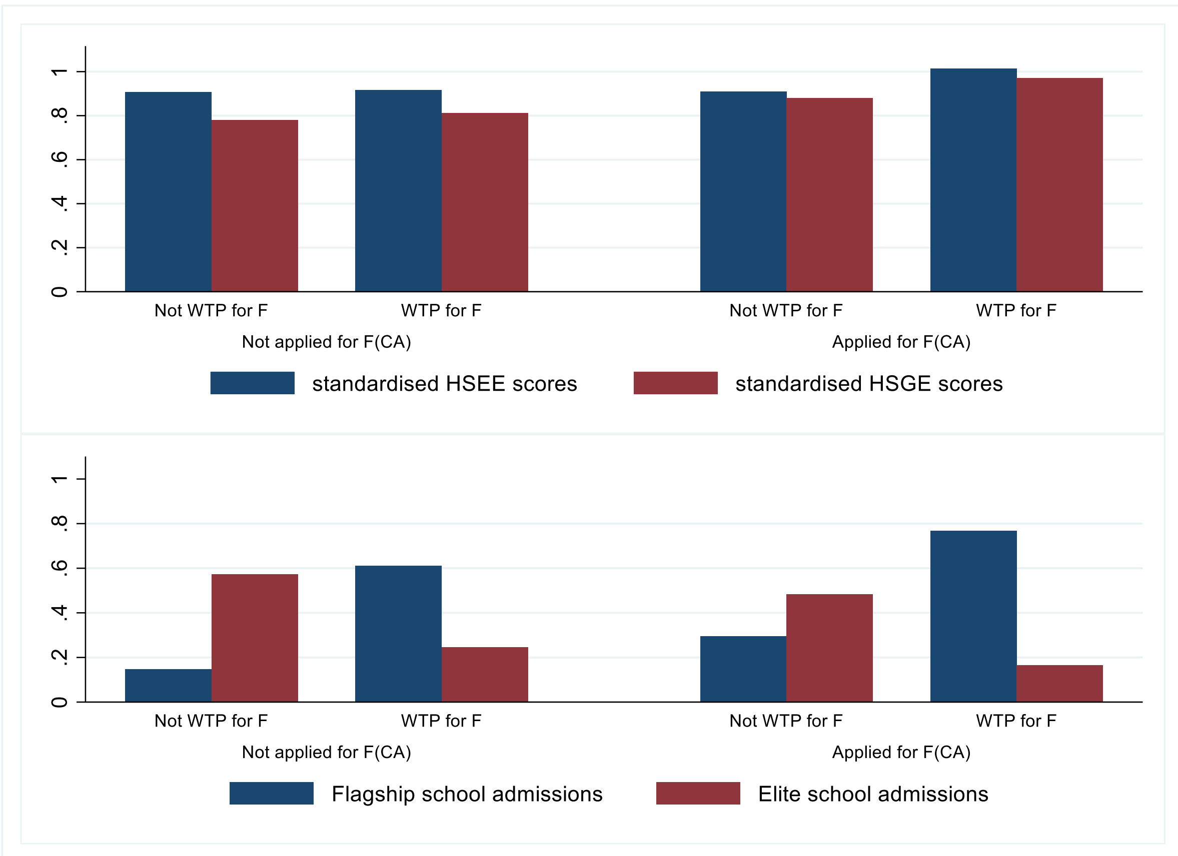


Table A2 in the Appendix show that the continuous measure of age (derived from detailed date of birth), gender, and county/district of *hukou* all easily pass the covariate smoothness test at the flagship school *unified-enrolment* cutoff, with robust p-values of at least 0.48.[21] Since some parental background characteristics, especially the CCP/political party memberships for both parents fail the test at the 5% level, we choose not to include any of them as covariates.[22] Our preferred RD specification in the following further robustness checks and heterogenous effect results is the Local Linear RD point estimator using the Epanechnikov kernel function with two-way MSE-optimal bandwidth selectors.

Within each application type, applicants are regarded as having the same school preferences (Dale and Kreguer 2002, 2014). Adjusting for differences in the probability of attending the more selective school types, the differences in the HSGE between applicants who are admitted through barely scoring above the application-type-specific HSEE cutoff and those who barely miss out, identifies the unbiased causal effect of attending the relevant selective school type, conditioning on the application type. Pooling across application types with different type-specific normalized cutoffs then gives the unbiased pooled causal effect. For applicants who are neither eligible for contextual admissions nor willing to pay for the selection-fee route in Column 1, there is virtually a sharp discontinuity at the 623 point cutoff, with the probability jumping by 98.1 percentage points. Indeed, one cannot reject a null of a 100 percentage point increase (i.e. perfect compliance) at any conventional significance level. For this group who are admitted purely on the basis of HSEE scores, the effect of barely making it to the attending flagship school is a **negative** 0.43 SD on HSGE scores, significant at the 1% significance level. In Column 2, WTP applicants but not eligible for CA would increase their probability of attending the flagship school by 57.1 percentage points if they score at least 606 points, the cutoff for *selection-fee* admission. However, the effect of flagship school attendance on HSGE

[21] Our choice of control variables is the same as in Hoekstra et al (2018), except for the omission of middle school fixed effects. Including 63 FEs makes no difference to the main findings, but it leads to larger standard errors in subsample analyses for applicants who are eligible for CA or willing to pay *selection-fees* due to limited sample sizes.

[22] These parental controls are significant predictors of application types. It turns out that the failure of the covariate smoothness test in parental CCP/Political Party Memberships only applies to those eligible for CA, suggesting that CA eligibility (determined by teacher assessments and exams in middle schools) might be subject to parental influence to some extent, unlike admissions under *unified-enrolment* and *selection-fee* channels according to HSEE scores and pre-registered school preferences).

Table 5: Heterogeneous treatment effects by application types, separately and pooled, Flagship School Cut-off

	Subsample Analysis			Pooled Sample	
Models	**Not eligible for CA & not willing to pay**	**Not eligible for CA & willing to pay**	**All Eligible for CA**	**No normalizing**	**Normalizing & pooling**
Cutoff	623	606	593	623	623/606/593
HSEE (running variable) mean [range]	601.3 [567, 655]	602.2 [567, 659]	605.5 [567, 656]	603.6 [567, 659]	603.6 [567, 659]
Elite school attendance	0.981	0.571	0.183	0.405	0.411
S.E	0.027	0.133	0.065	0.063	0.057
P (Robust)	0.000***	0.001***	0.003***	0.000***	0.000***
P-value (RD manipulation) test	0.614	0.076	0.320	0.040**	0.826
Std. HSGE score (SD)	-0.428	0.109	-0.042	-0.645	-0.322
S.E	0.150	0.412	0.549	0.194	0.157
P (Robust)	0.010***	0.784	0.994	0.003***	0.066*
Obs	855	301	1,241	2,397	2,397
Sample share (%)	35.7	12.6	51.8	100.0	100.0

Note: Conditional on HSEE scores no less than 567 (cutoff for *unified-enrolment* for the most selective normal school). ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels respectively.

scores for them is statistically insignificant. Column 3 shows that scoring at least 593 points for contextual admissions applicants (regardless of willingness to pay) increases the probability of flagship admission by a more modest 18.3 percentage points, but this **is** significant at the 1% level despite the highly fuzzy cutoff. However, the corresponding value-added estimate of flagship attendance is again indistinguishable from zero. It is worth noting that, if anything, the average HSEE scores for students who are either eligible for CA or willing to pay *selection-fees*, are higher than those for students who benefit from neither concession in Column 1. The last two columns show the pooled estimates, without and with normalizing with respect to the application-type-specific cutoffs. While both un-normalized and normalized pooling specifications show that barely scoring above the admissions threshold would increase flagship school attendance by about 41 percentage points, the estimated effect of attending flagship school on HSGE scores is only -0.32 of an SD under the preferred normalizing-and-pooling specification, half as large as the naïve specification. Note that the naïve specification fails the RD manipulation test of the assignment variable in an RD (McCrary 2008), at the 5%. This strongly indicates the naïve model is mis-specified, due to the crucial assumption of the random assignment of the cutoff in the RDD design failing to hold across all application types.

Figure 9: Normalized-and-pooling RDD plots, within 0.25 SD of flagship-elite cutoff

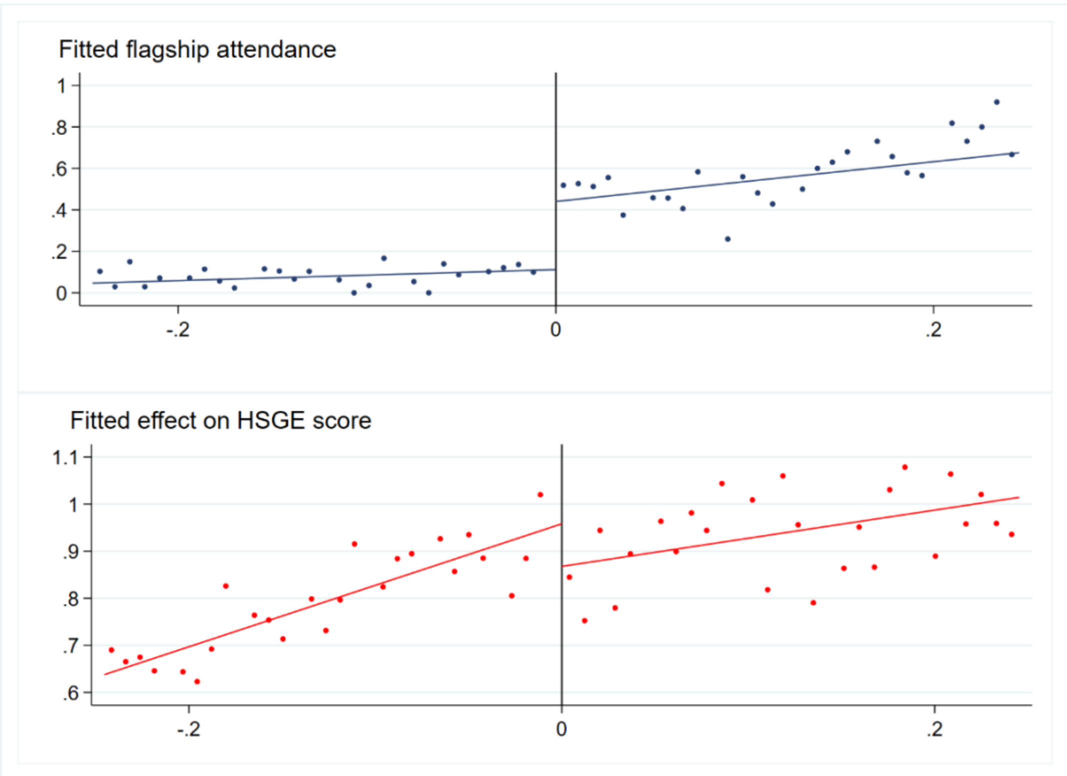


Figure 9 visualises the normalizing-and-pooling RDD specification but imposes the window length of 0.25 SD around the cutoff (corresponding to the last column in Table 6E). It confirms, in the top panel, a substantial positive jump in the effect of the running variable on flagship attendance; but, in the bottom panel, it confirms the negative discontinuity in the flagship attendance effect on the HSGE outcome.

To sum up, overlooking heterogeneity in school preferences across application types results in substantial over-estimation of the magnitude of the adverse effect of flagship attendance on HSGE scores, by a factor of two, for marginal students.

7.2 Robustness checks

Our preferred RDD specification is the normalizing-and-pooling model in the last column of Table 5 - with the Local Linear RD point estimator p(1) and Epanechnikov kernel function with two-way MSE-optimal bandwidth selectors. Table 6 shows the robustness of the preferred specification with respect to alternatives - including order of local polynomial kernel functional forms, bandwidth selectors, and the window lengths around the cut-offs.

Panel A checks the effect of omitting the covariates. Compared to column 1, which reproduces the benchmark specification, excluding covariates have virtually no effect on the point estimates but increase standard errors in both stages as predicted.

Panel B shows that using higher orders local polynomial density instead of the robust Local Linear RD point estimator p(1) in Column 1 does not have much impact on the statistical significance of the effect of flagship attendance. However, both the point estimates and the standard errors become larger, especially for the second-stage estimates.

Panel C suggests using the alternative triangular or uniform kernel function only results in slightly larger point estimate or standard error in the second-stage. However, the differences with the benchmark specification are insignificant statistically.

While our benchmark specification uses the two-way MSE-optimal bandwidth selector *msetwo*, Panel D tests the robustness of the RDD estimates with respect to the more common (one-way) MSE-optimal bandwidth selector, and to both the two-way and one-way CER (coverage error-rate) optimal bandwidth selectors. The point estimates of the negative flagship attendance effect on HSGE scores holds across all alternative bandwidth selectors, but with somewhat diminished significance level due to larger standard errors. Imposing a common running variable range potentially results in greater imbalance in the running variables across the cutoffs for some application types, because of the significant variation in the cutoffs.

Table 6: Robustness with respect to alternative specifications, Flagship School Cut-off

Panel A: With and without covariates

	With covariates	**Without covariates**
Elite school attendance	.411	.391
S.E	.057	.058
P (Robust)	0.000***	0.000***
Std. HSGE score (SD)	-.322	-.324
S.E	.157	.183
P (Robust)	0.066*	0.131

Panel B: Higher orders of local polynomial density

	p(1)	**p(2)**	**p(3)**
Elite school attendance	.411	.427	.440
S.E	.057	.065	.076
P (Robust)	0.000***	0.000***	0.000***
Std. HSGE score (SD)	-.322	-.311	-.373
S.E	.157	.183	.221
P (Robust)	0.066*	0.115	0.096*

Panel C: Alternative kernel functions

	Triangular	**Uniform**
Elite school attendance	.411	.419
S.E	.057	.064
P (Robust)	0.000***	0.000***
Std. HSGE score (SD)	-.314	-.273
S.E	.156	.176
P (Robust)	0.068*	0.136

Panel D: Alternative bandwidth selector

	mserd	**certwo**	**cerrd**
Elite school attendance	.401	.422	.418
S.E	.056	.067	.067
P (Robust)	0.000***	0.000***	0.000***
Std. HSGE score (SD)	-.303	-.291	-.359
S.E	.169	.184	.198
P (Robust)	0.109	0.128	0.083*

Panel E: Imposing symmetric window lengths (in SDs)

	Within 0.35 SD	**Within 0.25 SD**
Elite school attendance	.414	.418
S.E	.064	.067
P (Robust)	0.000***	0.000***
Std. HSGE score (SD)	-.317	-.365
S.E	.183	.198
P (Robust)	0.115	0.089*
Obs	1,940	1,565

Note: N=2,397 except in Panel E. Bandwidth selection procedures ***msetwo*** and ***mserd*** specify (two) separate and common Mean Squared Error-optimal bandwidth selectors respectively, while ***certwo*** and ***cerrd*** specify (two) separate and common coverage error-rate (CER) optimal bandwidth selectors, respectively. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels respectively.

Panel E checks the robustness of the benchmark specification to imposing symmetric window lengths around the application-type-specific cutoffs (before pooling). The results suggest that while imposing symmetric window lengths increase the magnitude of the second-stage RDD estimate (the negative effect of flagship school attendance on HSGE scores), narrowing the window lengths makes hardly any difference. It is worth noting that with window lengths of 0.25 SD (corresponding to about 25 HSEE score points), an elite school place is virtually guaranteed conditional on the application type for applicants who missed out on the flagship school admission. Overall, Table 6 show remarkable robustness of our benchmark model over alternative specifications, which tend to be only marginally less precisely estimated.

7.3 Heterogenous Effects by Gender, Area Type, and Academic Track

In Table 7 we further explore the heterogenous treatments by gender, for the full range of sample with HSEE scores at 567 or higher and the restricted sample with window lengths of 0.25SD around the cutoff. Scoring just above the cut-offs significantly increases the probability of flagship school attendance for both genders, but more so for girls. On the other hand, attending the flagship school has a statically significant **negative** effect on HSGE for girls only. The finding of a **more** negative effect for girls is consistent with Hoekstra et al (2018) who finds that the small but significant positive effect of flagship is driven by boys, and with Wu et al (2019) who show the positive magnet class effect within elite school is driven by boys.

Table 8 explores the heterogenous treatment effect by *hukou* location and window lengths. Students with semi-urban County Z *hukou* might be socio-economically disadvantaged through attending primary and middle schools with lower teacher quality and lesser school resources, compared to their urban centre counterparts. Table 8 shows that barely scoring above the cutoff has a significant positive effect on the probability of attending the flagship, which is more pronounced for students from the semi-urban County Z. Moreover, the negative effect of the flagship school on HSGE scores is only statistically significant for students from the semi-urban area. For urban students, the second-stage estimates are very close to zero.

Table 9 examines the heterogenous treatment effect by household *hukou* status and window lengths, where the household is classified as non-agricultural is either parent holds a non-agricultural *hukou* status. The effect of scoring above the admissions cutoff on flagship attendance is smaller for non-agricultural households than agricultural households, although both are significant at the 5% level at least. On the other hand, the magnitude of the adverse effect of flagship attendance on HSGE is larger for non-agricultural households, although the

Table 7: RDD estimates by gender and window lengths, Flagship School Cut-off

HSEE range/Window lengths	Full range (HSEE 567-659)		Within 0.25 SD of cutoff	
Gender	**Boys**	**Girls**	**Boys**	**Girls**
Elite school attendance	0.264	0.494	0.359	0.469
S.E	0.084	0.072	0.119	0.085
P (Robust)	0.006***	0.000***	0.004***	0.000***
Std. HSGE score (SD)	-0.206	-0.371	-0.334	-0.472
S.E	0.407	0.167	0.408	0.231
P (Robust)	0.713	0.045**	0.431	0.072*
Obs	1,062	1,335	692	873

Note: ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels respectively.

Table 8: Heterogenous effects by *hukou* location type and window lengths, Flagship School Cut-off

HSEE range/Window lengths	Full range (HSEE 567-659)		Within 0.25 SD of cutoff	
***hukou* location type**	**Urban**	**Semi-urban**	**Urban**	**Semi-urban**
Elite school attendance	0.373	0.463	0.371	0.564
S.E	0.070	0.084	0.085	0.114
P (Robust)	0.000***	0.000***	0.000***	0.000***
Std. HSGE score (SD)	0.020	-1.155	0.016	-1.108
S.E	0.227	0.314	0.293	0.349
P (Robust)	0.853	0.001***	0.970	0.007***
Obs	1,729	668	1,131	434

Note: ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels respectively.

Table 9: Heterogenous effects by household *hukou* status and window lengths, Flagship School Cut-off

HSEE range/Window lengths	Full range (HSEE 567-659)		Within 0.25 SD of cutoff	
household *hukou* status	**Non-agricultural**	**Agricultural**	**Non-agricultural**	**Agricultural**
Elite school attendance	0.245	0.461	0.276	0.468
S.E	0.100	0.066	0.123	0.077
P (Robust)	0.030**	0.000***	0.040**	0.000***
Std. HSGE score (SD)	-0.411	-0.281	-0.782	-0.256
S.E	0.428	0.187	0.503	0.243
P (Robust)	0.431	0.153	0.118	0.341
Obs	1,003	1,394	636	929

Note: Household classified as non-agricultural if any parent holds non-agricultural *hukou*. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels respectively.

second-stage estimates are statistically insignificant for both household types. We interpret this as evidence that parental school preferences, proxied by application types, have adequately picked up differences in socio-economic backgrounds at the student level.

The HSGE contains seven subjects which can be classified into two tracks, according to their relevance to the track-specific CEE. The Social Studies (Arts) track includes Politics, History and Geography, while the Science track includes Physics, Chemistry, Biology, and Informatics. While high school students must study courses in both tracks in the first years of high school, they have to make up their minds on the specific track to specialise in before Grade 12 and take the track-specific CEE which determines the subject-specific university degree course on which they can be enrolled at a particular HE institution.

While we do not observe students' eventual track choice in our sample, it is nevertheless interesting to explore the heterogenous effect of flagship school attendance on track-specific HSGE subject performance, by the relative performance in HSEE science related subjects. Cannon et al (2022) show that while a placement in the high-achieving classroom in flagship schools improves maths test scores by 0.23 SD, there are no significant effect on Chinese or English. It is conceivable that the flagship attendance effect also depends on one's **relative** strength in science and maths as opposed to other HSEE subjects including Chinese and English, as measured by the percentile rank in those two tracks before starting high school.[23]

Tables 10 presents the heterogeneous flagship effects by the relative strength in science related HSEE subjects, on social studies and science related subject scores in HSGE. As expected, the mean HSEE total scores are virtually identical between those who have a comparative strength in science and their counterparts who have a comparative advantage in non-science subjects.

Panel A shows little evidence of a consistent and statistically significant negative impact of flagship attendance on HSGE performance overall or by academic tracks, for students who are relatively strong in HSEE science track. On the other hand, Panel B indicates that the detrimental effect of attending the flagship school on marginal students is concentrated among students who have the same total HSEE scores but are **relatively** lower ranked in HSEE science subjects. When the window length is restricted to 0.25 SD around the relevant flagship cutoff, the negative effect becomes more pronounced and only statistically significant for Social

[23] Both Hoekstra et al (2018) and Wu et al (2019) show that the likelihood of majoring in Social Studies (Arts) vs Science is smooth across all HSEE cutoffs.

Studies subjects in HSGE. These striking results show that compared to their school mates who had a comparative advantage in science-related subjects upon entry into the flagship school, marginal students who were less good at sciences and maths (but better at Chinese, English, History, Geography and Politics) substantially underperform in HSGE subjects across the board, even in subjects that they might be expected to have a comparative advantage in. To the extent that boys (girls) are more likely to major in science (social studies), this finding contributes to the more pronounced negative flagship effect for girls in Table 7.[24]

Table 10: Heterogenous effects by HSEE science track relative strength and window lengths, Flagship School Cut-off

A: Relatively strong in HSEE science track

HSEE range/ window lengths		**Full range (HSEE 567-659)**			**Within 0.25 SD of cutoff**	
HSGE subjects	**Social Studies**	**Science**	**All**	**Social Studies**	**Science**	**All**
Flagship attendance	0.338	0.326	0.320	0.392	0.381	0.391
S.E	0.076	0.071	0.071	0.100	0.096	0.098
P (Robust)	0.000***	0.000***	0.000***	0.001***	0.001***	0.001***
Std. HSGE score	-0.198	-0.352	-0.401	-0.482	-0.490	-0.542
S.E	0.380	0.306	0.250	0.510	0.351	0.289
P (Robust)	0.684	0.308	0.167	0.335	0.206	0.074*
Obs		1,189			792	
HSEE mean		603.3			602.7	

B: Relatively weak in HSEE science track

HSEE range/ window lengths		**Full range (HSEE 567-659)**			**Within 0.25 SD of cutoff**	
HSGE subjects	**Social Studies**	**Science**	**All**	**Social Studies**	**Science**	**All**
Flagship attendance	0.453	0.438	0.455	0.458	0.449	0.440
S.E	0.087	0.085	0.085	0.110	0.097	0.102
P (Robust)	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
Std. HSGE score	0.174	-0.440	-0.271	-0.817	-0.426	-0.468
S.E	0.267	0.334	0.235	0.403	0.388	0.344
P (Robust)	0.642	0.251	0.293	0.029**	0.400	0.200
Obs		1,208			773	
HSEE mean		603.9			602.4	

[24] Wu et al (2019) show that while boys account for 49% of the sample overall, they represent 76% of the Science track but only 18% of the Social Studies track.

Note: HSEE science track relative strength indicates having a higher percentile rank in the total scores of HSEE science and maths, relative to the percentile rank in the total scores of other HSEE subjects, among all flagship school attendants including students excluded from the analytical sample.

7.4 Discussions on the effect of flagship attendance

Our finding of a lack of positive causal effect of attending elite schools differs from the general finding from developing countries of a significant positive effect of attending the flagship school on academic outcomes. However, it is consistent with existing Chinese evidence based on RDD, especially in urban settings (Dee and Lan, 2015; Zhang, 2016; Anderson et al 2016; Hoekstra et al 2018). On the other hand, our finding of a large negative effect of attending a flagship school is at odds with the small positive and significant effect of attending Tier 1 (flagship) elite school in China suggested by Hoesktra et al (2018). The difference is likely to be explained, in part, by the different settings. First, while we can only study the effect on the HSGE scores, their focus is on the performance in the more high-stakes CEE which is the sole determinant of access to elite universities in China. Previous studies in the US context suggest that achievement gains are likely to be more pronounced in high-stakes exams (see. e.g. Jacob, 2007; Corcoran et al 2011). Second, while they restrict the sample to suburban students who can only attend a school in the district or county of *hukou* registration, our sample includes all students in the whole urban area including the suburb and the immediately adjacent semi-urban county, which implies more choices and more intense competition for the only flagship school in the whole prefecture. Third, we also allow for admission routes other than *unified-enrolment*, which includes a significant minority of students with lower HSEE scores admitted either by paying extra *selection-fees* or through CA.

Another potentially important channel underlying the negative and significant effect of attending flagship schools which is largely overlooked in the previous literature, is the almost universal within-school tracking in high schools in China (Dee and Lan 2015; Wu et al 2019, Canaan et al 2022). Canaan et al (2022) also show that the school resources are disproportionately concentrated on high-achieving classrooms in the flagship school they study, suggesting that flagship schools place more emphasis on preparing their best students for the CEE, the sole determinant of access into China's elite universities. It is worth noting that the Chinese system, with its strong teaching tracking and ability sorting, is very similar to that of Romania, a country that was also historically influenced by the elitist Soviet educational system (Pop-Eleches & Urquiloa 2013).

Recall that the flagship effects differ substantially across different types of applicants in Table 5. The flagship effect is only negative and statistically significant, at -0.43 SD, for applicants who are neither eligible for CA nor WTP for selection-fees. For applicants who are eligible for CA or WTP the *selection-fees*, the point estimates are 0.11 and -0.04 SD, respectively, and statistically indistinguishable from zero.

The heterogeneous effects of flagship attendance across applicant types are indeed consistent with the prevalence[25] of magnet classes in all types of elite schools. For applicants who are eligible for CA or willing to pay *selection-fees*, failing to cross the lower admission cutoffs (at 606 and 593 respectively, instead of 623 for the *unified-enrolment*) imply that they will almost certainly be placed in regular rather than classes in elite schools. In contrast, for applicant who are neither eligible for CA nor willing to pay selection-fees, just missing out on flagship enrolment means they are very likely to be in the top 15% of the HSEE distribution among elite school entrants and hence benefit from the high-achieving classrooms. This implies that, in the absence of magnet classes, the flagship effect is expected to be indistinguishable from zero. [26]

Dee and Lan (2015) provide direct evidence that *selection-fee* students who score barely above the lower *selection-fee* admission cut-off are no more likely to study in the Science track than student attending non-elite schools with similar HSEE scores. Cannan et al (2022) further show that the positive magnet class effect is more pronounced for math, and more muted for Chinese and English. This implies that marginal students fail to take full advantage of attending elite schools which tend to have strong academic records in the sciences, partly because of concentration of higher-quality teachers.[27] In our case, we do not observe students' academic track choices in their final year of high school in our data. However, our results in Table 10 are consistent with Dee and Lan (2015) and Cannan et al (2022) in the sense that the negative effect

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[25] It is also interesting to note that our flagship cutoff is the most selective of all RDD studies using Chinese data. In the full sample with students scoring below 400 score points, the flagship school only admits 18.7% of students, with the *unified-enrolment* cutoff corresponding to the top 8% HSEE threshold. This is above the top 21% in Zhang (2016), top one-third in Hoekstra et al (2018), top 50% in Park et al (2015) and top 60% in Dee and Lan (2015).

[26] In Appendix Table A1, we calculate the 85th percentile within each school type to get an approximate threshold for admission to the magnet class. We find that the predicted magnet class cutoff for elite schools (609) is above the flagship cutoffs for CA (593) or WTP (606) routes, which implies that applicants who fail the CA or WTP routes for flagship are unlikely to be placed in magnet classes in elite schools, unlike their *unified-enrolment* counterparts.

[27] Hoekstra et al (2018) show that the share of science track students rises steeply in school selectivity, rising from 35% in the bottom two tiers to 66% in Tier 1 (flagship).

of flagship attendance for marginal students is more pronounced for students who have displayed a comparative disadvantage in science-related subjects in the HSEE. In particular, the negative effect of flagship attendance is even larger, and is more statistically significant, in the HSGE Social Studies track subjects where they were expected to have a comparative advantage.

More generally, the negative effect of attending flagship schools is consistent with the "*small-fish-big-pond*" effect (see Marsh et al 1995; Murphy and Weinhardt 2020; Denning et al 2022). To the extent that one's ranking matters for outcomes, marginal students who are barely eligible for entry into the flagship schools might choose to study in its relatively weaker social studies track to avoid stigma or intense competition (Dee and Lan 2015; Canaan et al 2022).

It is also conceivable that marginal students prefer flagship schools on the basis of academic returns which are not measured by HSGE scores (e.g. elite school education might better prepare the marginal students from advantaged SES backgrounds for college education overseas) even when they do not fare as well in the Chinese HE system. The literature on private schools also suggest that the *non-academic* returns could be important, for instance through the existence of social networks. For example, schoolmates in flagship schools might be expected to become local elites in the future since the context here is a society with strong social norms and low social mobility.

7.5 The Effects at the elite-normal and normal-private school cutoffs

To avoid repetition, we relegate the corresponding normalizing-and-pooling RDD estimates accounting for school preferences at the elite-normal and normal-private school cutoffs to the Appendix Tables A3. The results are fully consistent with the accumulative multiple cutoffs RDD results in Section 6 earlier, with no statistically significant effects on HSGE scores found for attending more selective schools, whether in application type-specific or pooled specifications.

8. Conclusions

Using novel administrative data for the population of urban students in one prefecture in north central China, who started high school in 2010, we present new evidence on the causal effect of attending academic more selective high schools on high school exit exams.

Cumulative multi-cutoff RDD estimates based on the publicly announced admission cut-offs of city-wide High School Entrance Exam (HSEE) scores show, in a unified setting covering all school selectivity types across the whole ability distribution, no evidence of any positive effect of attending more selective schools on high school exit exam scores at three different thresholds for high school selectivity. This is broadly consistent with the existing RDD evidence based on urban settings in China (Dee and Lan, 2015; Zhang, 2016; Anderson et al 2016; Hoekstra et al 2018). It is also in accordance with the RDD evidence for developed countries in general (e.g. Clark, 2010; Abdulkadiroglu et al 2014; Dobbie and Fryer, 2014).

However, attending the flagship school relative to elite schools is found to have a large and statistically significant **negative** effect for marginal students in our setting. This is corroborated by the normalizing-and pooling RDD estimates accounting for school preferences as revealed in the high school application. Subsample RDD analysis by application types suggests that this is driven by *unified-enrolment* students admitted strictly according to the HSEE scores, rather than students who are either eligible for contextual admissions or express a willingness to pay *selection-fees* in return for lower HSEE entry requirements. This implies that the negative flagship school effect would have shifted towards zero, in the absence of magnet classes within flagship and elite schools.

As far as the HSGE are concerned, our fuzzy RDD results suggest that it does not really pay to attend more selective high schools in China, for students who are at the margin of admission cut-offs, regardless of the degree of school selectivity or high school preferences. In particular, attending the flagship school is shown to have large and precisely estimated adverse effects for marginal students. More generally, our findings indicate that attending more academically selective schools has, at best, no value-added and potentially may even harm students' academic achievement at the flagship school.

These results are robust to alternative specifications of the RDD estimator, including covariates, using alternative orders of local polynomial density, kernel functional forms, bandwidth selectors, and variations in the window lengths around the admission cut-offs. Moreover, the adverse effects of flagship on HSGE scores are more pronounced for girls, students from the semi-urban area and students who performed *relatively* worse in the science track subjects in the HSEE.

Our findings have important implications for students and parents, as well as policy makers. They suggest that the widely held belief that competition and superior peer quality at more selective schools can only enhance students' academic achievements could be quite misleading. Specifically, paying substantial *selection-fees* to attend flagship schools characterised by within-school ability tracking and an overemphasis on science track education could be counter-productive for marginal students, especially girls, students from the semi-urban area or students who do not have a comparative strength in science-related subjects by the end of compulsory education. It seems unlikely that these characteristics of flagship schools is unique to China and, if so, our results could have external validity outside China.

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Appendix A:

Table A1: School-level characteristics, by high school type

	Flagship	**Elite**	**Normal**	**Private**
School characteristics:				
Number of schools	1	2	4	11
HSEE score	601.6	56.6	524.6	412.5
Standardized HSEE	0.911	0.548	0.155	-0.945
Unified-enrolment cutoff	623	587	523	300
Predicted cutoff for magnet class (85^{th} percentile)	635	609	581	511
Number of classes (across 3 grades)	72	54	28	29
Average class size	62	62	63	54
Area size (1,000 square meters)	55.8	67.8	23.8	24.6
Books in library (1,000)	160.0	47.2	61.0	19.0
Expenditure per student (CN¥ 1,000):				
Direct expenditure	9.4	9.7	8.3	6.1
Staff expenditure	3.6	3.1	4.2	2.3
Public expenditure	2.0	2.7	2.1	1.6
Scholarship expenditure	0.28	0.39	0.29	0.48
Teacher characteristics (dedicated high schools only):				
Number of schools	1	2	1	5
Total number of teachers	224	192	100	78
Share male	0.379	0.449	0.350	0.372
Share with less than 10 year's experience	0.156	0.244	0.160	0.762
Share with 10-24 year's experience	0.799	0.715	0.820	0.005
Share with at least 25 years' experience	0.045	0.041	0.020	0.233
Share with Bachelor's degrees or above	0.996	0.994	0.990	0.702
Of which, with postgraduate degrees	0.085	0.159	0.020	0.010
Share with Senior Rank or above	0.321	0.186	0.190	0.027
Of which, with Special-Grade (highest)	0.054	0.017	0.020	0.000
Student-teacher ratio	20.0	17.7	19.4	19.0
Per teacher training exp. (CN¥ 1,000)	2.1	1.0	4.3	3.6
Combined student share (%)	18.7	26.5	27.3	27.6

Note: Predicted magnet class cutoff and combined student share are based on all students in the sample including those with HSEE score point under 400 (N=6,466). Teacher characteristics based on dedicated high schools only (i.e. excluding high schools with affiliated middle school sections).

Table A2: Covariate Smoothness Tests at the flagship-elite school cutoff

	RD Effect	Robust p-value
Age	-.078	.520
Boy	-.085	.504
CBD	.009	.741
Suburb	-.048	.481
County Z	.037	.568
Parental characteristics:		
Father unemployed/redundant/retired	-.002	.816
Father agricultural *hukou*	.021	.638
Father non-agricultural *hukou*	-.090	.242
Father status missing	.059	.304
Father CCP/Political Party member	-.227	.011**
Mother unemployed/redundant/retired	.037	.259
Mother agricultural *hukou*	-.067	.422
Mother non-agricultural *hukou*	-.033	.649
Mother status missing	.111	.073*
Mother CCP/Political Party member	-.098	.035**
Obs	2,397	

Note: Same as the pooled sample for in Table 5, i.e. conditional on HSEE scores no less than 567 (cutoff for unified-enrolment for the most selective normal school). ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels respectively.

Table A3: Heterogeneous treatment effects by application types, separately and pooled

The Elite/Normal School Threshold

Sample	*Subsample Analysis*			*Pooled Sample*	
Models	***Not Eligible for CA & not willing to pay***	***Eligible for CA & not willing to pay***	***Willing to pay***	***No normalizing***	***Normalizing & pooling***
Elite school attend.	0.217	0.284	0.151	0.318	0.345
S.E	0.131	0.112	0.142	0.072	0.061
P (Robust)	0.205	0.031^{**}	0.427	0.000^{***}	0.000^{***}
Std. HSGE score (SD)	-1.077	0.365	0.915	0.064	-0.486
S.E	0.970	0.745	2.189	0.272	0.340
P (Robust)	0.185	0.741	0.784	0.891	0.131
HSEE (running variable) mean [range]	576.4 [467, 622]	575.4 [471, 621]	564.1 [467, 622]	571.1 [467, 622]	571.1 [467, 622]
P-value (RD manipulation) test	0.225	0.258	0.525	0.910	0.290
Cutoff	587	557	532	587	587/557 /532
Obs	696	477	804	1,977	1,977

Note: Conditional on HSEE between 467 (cutoff for selection-fee admissions mode for the least selective normal school) and 622 (right below the unified admissions cutoff for flagship) and have applied to at least one elite school under the unified mode.). ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels respectively.

The Normal/Private School Threshold

Sample	*Subsample Analysis*		*Pooled Sample*	
Models	***Not willing to pay***	***Willing to pay***	***No normalizing***	***Normalizing & pooling***
Normal school attend.	.466	-.078	.248	.268
S.E	.082	.131	.069	.070
P (Robust)	0.000^{***}	0.609	0.001^{***}	0.001^{***}
Std. HSGE score (SD)	-.512	-.971	-.550	-.329
S.E	.252	2.400	.394	.351
P (Robust)	0.202	0.732	0.502	0.445
HSEE (running variable) mean [range]	505.0 [400, 556]	490.1 [400, 556]	498.4 [400, 556]	498.4 [400, 556]
P-value (RD manipulation) test	0.084^{*}	0.852	0.107	0.356
Cutoff	532	482	532	532/482
Obs	920	728	1,648	1,648

Note: Conditional on HSEE below 557 (cutoff for contextual admissions mode for elite school E2) and have applied to at least one normal school under the unified mode.). ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels respectively.

Appendix B: High School Applications

Table B1: School-Mode Preferences in the High School Applications Database

School -mode choice rank	Admission Groups	Maximum choices in group	Within-group preference rank	Feasible set of Schools
1st	Group 1: *Talent mode* (sports/art)	1	1st	Any
2nd	Group 2: *Contextual Admissions (F*	2	1st	2
3rd	*and E2 only)*		2nd	1 remaining
4th	Group 3a: Flagship *unified*	2	1st	1 (F only)
5th	Group 3b: Flagship selection-fee		2nd	1 (F only)
6th	Group 4a: Elite and Normal,	4	1st	6 (E or N)
7th	*unified* only		2nd	5 remaining
8th			3rd	4 remaining
9th			4th	3 remaining
10th	Group 4b: Elite and Normal,	2	1st	6 (E or N)
11th	*selection-fee only*		2nd	5 remaining
12th	Group 5: All Private Schools, all	2	1st	11 (P1-P11)
13th	modes (no CA option)		2nd	10 remaining

Note: F, E, N and P stand for Flagship, Elite, Normal and Private schools, respectively. Admission proceeds by group, and then preferences within-group. All applicants are allowed a maximum of 13 school-mode choices out of 18 feasible public high schools, consisting of 1 Flagship, 2 Elite, 4 Normal and 11 Private schools.

Timeline of the Admissions Process

Using 2009 high school admissions in the prefecture (which is fully documented) as an example, the timeline of the admissions process is follows:

(1): *Exam:* The High School Entrance Exam (HSEE) exams were conducted on 20th-22nd June.

(2): *Application:* After the exam but before results are known, students complete the High School (HS) application form. Admission proceeds strictly by the order of the Admission Group, then order of school-mode choice rank within-group (see Table B1). Applicants can list up to 13 school-mode combinations in total for academic high schools.[28]

- Group 1 (*1st choice*): *talent* mode. Limit of 1 entry (optional). For students with sports/art talents only (the few qualified students need only to score 50-60% of the *unified-enrolment* cut-off).
- Group 2 (*2nd and 3rd choices*): *CA* (Contextual Admissions) mode, 2 entries (optional). Only relevant for students with 3-year full history in the designated disadvantaged middle schools. Note that both the quota (%) and the CA cut-offs are pre-announced. In the unlikely event that the quotas were not filled, then any remaining places will go to Group 3 below.
- Group 3a (*4th choice*): Flagship school F, *unified-enrolment* mode only. This is a strategy-proof option that any academically able student would have chosen. All

[28] Students can also apply to 6 other post-compulsory education options beyond academic high school education in the following order: general teacher (*normal*) schools, 5-year advanced vocational college, kindergarten/special-education teacher schools/colleges, Tier 1 general technical secondary schools, Tier 2 general technical secondary schools, and other vocational high (secondary) schools. For each option, applicants can choose 1 preferred institution and 1 reserve institution.

students who make the pre-announced *unified-enrolment* mode cut-off get a place, regardless of their Group 3b choice (for the *selection-fee* mode).

- Group 3b (*5th choice*): Flagship school F, *selection-fee* mode only. This is optional choice to indicate the willingness to pay the selection-fee to attend F, if HSEE is below the cutoff for *unified-enrolment* (i.e. Group 3a) but above the *selection-fee* cut-off. Note that both the quota for the selection-fee mode and its cut-off threshold were also announced before admission process starts.
- Group 4a (*6th-9th choices*): Up to 4 ranked choices for Elite and Normal Schools, *unified-enrolment* mode only.
- Group 4b (*10th-11th choices*): Up to 2 ranked choices for Elite and Normal Schools, *selection-fee* mode only. These are optional choices to indicate willingness to pay to attend up to two Elite or Normal schools.
- Group 5 (*12th-13th choices*): Up to 2 ranked choices for Private schools only.

(3) *Centralised admission procedure* (for all academic high schools):

On July 7th, the City Education Bureau released the HSEE results to the District Admissions Service and the middle schools from which students graduated, together with the Tier 1 (Flagship School F only) admission cut-offs (for *unified-enrolment*). Students can check their results in person, by phone or online. Between 8th-12th July, students can request to have their scores re-checked for a fee (by filling in a form). Then:

- Tier 1 admission (only applies to Flagship School F) between 13th-15th July.
- After the conclusion of Tier 1 admission, with a full list of admissions announced online and in local newspapers, the City Education Bureau released the Tier 2 admission cut-offs for all remaining public high schools, including elite schools E1 and E2.
- Tier 2 admission took place during 15th-16th July. This concludes the elite school admission stage.
- After the conclusion of Tier 2 admissions and the public release of the full admission lists, the City Education Bureau released the admission cut-offs for lower tiers.
- Clearing *(bulu):* There is also a round of clearing at the beginning of August for unfilled general HS places (virtually irrelevant for elite schools).

Note that admissions of other types of post-compulsory education only procced after the conclusion of academic high schools by 20th August, also strictly according to the listed preferences in the application form.