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Using admission lotteries to estimate heterogeneous effects of elite schools

Hessel Oosterbeek Nienke Ruijs Inge de Wolf*

Abstract

This paper studies the effects of enrollment in an elite school on students' achievement. We use that elite schools in Amsterdam are often oversubscribed and admission is based on lotteries. Our results show that elite schools have negative effects on achievement of students who just qualify for the highest academic track and positive effects on achievement of students from the top of the baseline ability distribution. These results reconcile contrasting findings from previous studies that use regression discontinuity designs. We also find that value-added estimates of the effects of elite schools are severely biased. *JEL*-codes: I21, I24, C26.

1 Introduction

Secondary-school students in Amsterdam who are placed in the highest academic track, can choose between two types of schools: comprehensive schools that offer multiple tracks and elite schools that only offer the highest track.[1] Elite schools are popular and therefore often oversubscribed. We take advantage of the fact that admission to oversubscribed schools is based on lotteries to analyze the effects of elite schools on student achievement. Knowledge about these effects is important for parents who have to choose the type of school for their child. It is also important for policymakers who decide about school capacities and assess school quality.

Existing evidence about the effects of elite schools, or of better schools, on student outcomes is mixed. Hastings and Weinstein (2008), Jackson (2010) and Pop-Eleches and Urquiola (2013) report positive effects, Cullen et al. (2006), Clark (2010), Abdulkadiroğlu et al. (2014), Dobbie

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[1] The official Dutch name is not "elite" but "pre-university track only" (*categoraal vwo*). Elite is adequate because – as we will show below – these schools attract better performing and higher SES students.

and Fryer (2011), Lucas and Mbiti (2014), Beuermann and Jackson (2018), Wu et al. (2019) and Barrow et al. (2020) find effects that are not substantially and significantly different from zero, and Abdulkadiroğlu et al. (2018) even report negative effects.[2] In the settings that most of these papers study, admission is based on a qualifying score. This gives rise to a regression discontinuity design, which identifies treatment effects for students with a qualifying score just above the admission threshold of the school to which they are admitted. Treatment effects for these students may differ from those for students with higher scores. The admission lotteries used in Amsterdam allow us to investigate heterogeneous treatment effects by ability because lottery winners and losers are equally divided over the entire (qualifying) baseline ability distribution.[3]

We use data from cohorts that started secondary education in the years 2006 to 2010. During these years, the six elite schools in Amsterdam conducted a total of ten admission lotteries with 1115 participants. Because some of the students who lost a lottery are placed in an elite school that did not have a lottery in that year, we use an instrumental variable approach to address this noncompliance.

Enrollment in an elite school is a composite treatment. We show that in our setting the treatment implies an increase in school quality as measured by criteria reported by the Dutch Inspectorate of Education. It also entails a change in the composition of the peer group. Classmates in elite schools score higher on baseline ability measures and come from more affluent social backgrounds than classmates in comprehensive schools.

Considering the entire sample of lottery participants, we find that enrollment in an elite school lowers the probability to obtain a diploma from the highest track on time or with at most one year delay. At the same time, we also find that enrollment in an elite school increases the probability to obtain a diploma from the highest track with a high GPA. Further analysis reveals that these findings are the result of negative effects on the achievement of some students and positive effects on the achievement of others. More specifically, enrollment in an elite school lowers the probability to graduate from the highest track on time by 22 percentage points for students from the lower half of the baseline ability distribution, and increases the probability to graduate from the highest track with a high GPA by 17 percentage points for students from the top half of the baseline ability distribution.

These differential effects suggest an explanation for the mixed findings from previous studies that rely on regression discontinuity designs. These studies identify treatment effects for students with a qualifying score close to the admission threshold. If in our setting admission would have been determined by a threshold on the baseline ability score instead of admission lotteries, the threshold would have affected students from the bottom half of the baseline ability distribution.

[2]Table A1 in the appendix provides details of these studies.

[3]Cullen et al. (2006) and Dobbie and Fryer (2011) who also use admission lotteries find little evidence for differential treatment effects by baseline ability. Some of the studies that use an RD design also report treatment effects by baseline ability level. This, however, compares treatment effects across students who applied to schools with different admission thresholds.

In that case we would have concluded that elite schools affect academic achievement negatively. With smaller capacities of the oversubscribed schools, an admission threshold would, however, have affected students from the top half of the baseline ability distribution. In that case we would have concluded that elite schools affect academic achievement positively.[4]

When we compare the effect estimates based on admission lotteries with effect estimates obtained through a value-added approach (cf. Deming, 2014), we find that in our setting value-added estimates are severely biased. After conditioning on a rich set of information measured at baseline, the value-added estimate points to a significant *increase* of 13 percentage points in the probability to obtain the diploma with at most one year delay whereas the lottery-based estimate indicates a significant *decrease* of 8 percentage points of the same outcome. Opposite results are also found for other outcomes. Further analysis of the sources of selection bias in value-added estimates reveals that this is due to winning compliers having worse outcomes than always takers and students who are placed in an elite school with priority, as well as to losing compliers having better outcomes than students in comprehensive schools who did not participate in the admission lotteries for elite schools.

Our results also speak to the literature on school choice and competition which often assumes that parents know which school fits the needs of their child best. The effects that we estimate pertain to students who applied to an elite school and thus wanted to enroll in such a school. Our results indicate that a sizable share of parents choose a school that is not the best choice for their child in terms of academic achievement. These parents are possibly misled by the favorable results of elite schools on measures of school performance that ignore selection bias. Informing parents about the heterogeneous causal effects of elite schools may improve the match of students to schools.

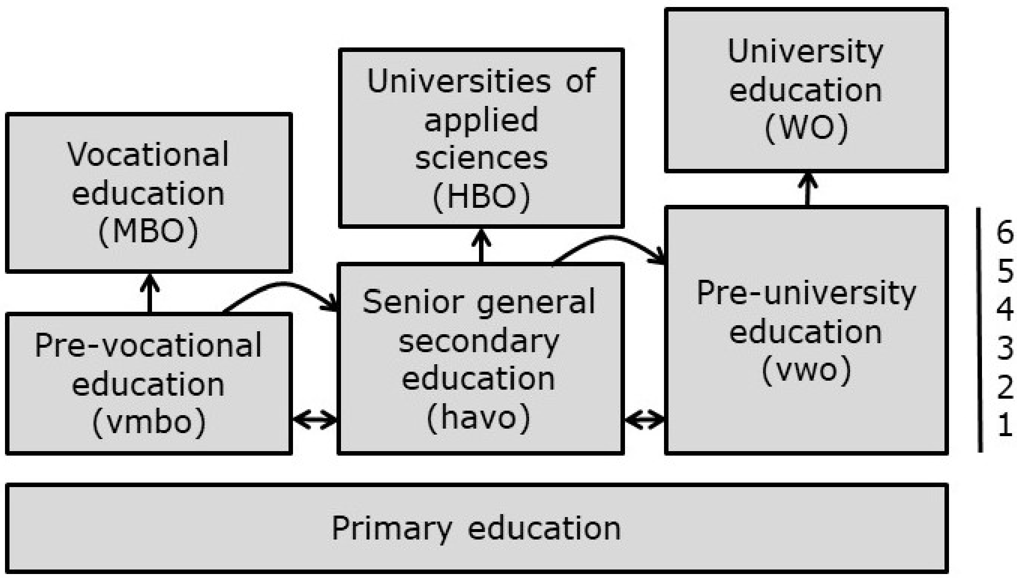
This paper proceeds as follows. Section 2 provides background information about Dutch secondary education and describes the secondary school choice and admission lottery system in Amsterdam. Section 3 describes the data. Section 4 explains the empirical strategy and shows the results from lottery balancing tests. Section 5 characterizes the treatment in terms of peer characteristics and secondary school quality. Section 6 presents the results. Section 7 concludes.

2 Context

The elite schools in this study are secondary schools in Amsterdam, which are part of the public school system in the Netherlands. This section provides a brief description of the relevant context for cohorts that started secondary education in 2006 to 2010. It first describes the general context

[4] Beuermann and Jackson (2018) also discuss the mixed findings from previous studies. They use a regression discontinuity design and find that preferred schools do not improve short-run test scores. To test whether this null effect is due to school impacts being different for marginal students than for the average student, they compare their RD estimates with estimates of school fixed effects from a value-added specification. They find no significant differences and interpret this as evidence that in their setting effects are the same for marginal and average students.

Figure 1. The Dutch school system



of secondary education in the Netherlands and then the specific context of secondary school choice and admission lotteries in Amsterdam.

2.1 Secondary education in the Netherlands

At the start of secondary education, around the age of 12, students in the Netherlands are streamed into three academic ability tracks. Figure 1 depicts this. The lowest track (pre-vocational education) lasts four years and gives access to vocational education programs. The intermediate track (senior general secondary education), takes five years and gives access to universities of applied sciences (professional colleges). The highest track (pre-university track) takes six years and gives access to university education. Depending on student achievement and school policies, students can change track during secondary education. Students can matriculate into a higher track after graduating from a lower track.

Elite schools are only an option for students in the highest track. Students are streamed into this track on the basis of their score on a nationwide exit exam and the recommendation of their teacher in the final year of primary school. Elite schools only offer the highest track and typically require students to take courses in Latin and Old Greek. The alternative are comprehensive schools that offer the highest track in combination with one or two of the other tracks. Enrollment in a comprehensive school is the counterfactual treatment in our analysis; there is no private school sector to which losers of admission lotteries can resort.[5]

[5]In 2009, only 0.3% of Dutch secondary school students attended a privately funded school (Dutch Inspectorate of Education, 2010). Schools can request a voluntary parental contribution. The indicated amounts for these

Students in the Netherlands have free school choice, they are not restricted by catchment areas or school fees. Government funding is nationally determined and largely depends on student numbers. Secondary schools receive additional funding for students from disadvantaged backgrounds through a neighborhood based funding scheme. The quality of education is monitored by the Dutch Inspectorate of Education. Since the 1990's, the Inspectorate's quality measures are public information and can be found on the Inspectorate's website and in newspaper rankings.

In the final years of secondary education, students specialize in one out of four fields of study: science, health, social sciences or humanities. Secondary schools have to follow national curriculum guidelines and all students take national exit exams at the end of secondary school. These exit exams count for 50% of the final grades, the other 50% is determined by school-specific exams taken in the last two or three years of secondary education.

The takeaway for our research question is that funding, curriculum and final exams are the same for all students in the pre-university track, independent of whether they are enrolled in an elite school or a comprehensive school.

2.2 Secondary school choice and admission lotteries in Amsterdam

Amsterdam is the capital and largest city of the Netherlands, it has about 750,000 inhabitants. Every year around 6000 students transfer from a primary school to one of the around 55 secondary schools.

In 2005, the secondary schools in Amsterdam introduced a centralized school assignment system using a version of the so-called Boston mechanism.[6] In this system each student applied to one school in the first round. Schools that were not oversubscribed accepted all students who applied in this round. Oversubscribed schools accepted all students with priority, and ran an admission lottery for the remaining places.[7] Students who lost the admission lottery in the first round had to apply again and could then only choose from the schools that still had vacant places.[8]

Of the schools that offer the highest track, only elite schools ran lotteries for the cohorts that we consider. For these cohorts, there were six elite schools in Amsterdam. Five of these schools require students to take courses in Latin or Old Greek, while in the sixth school these are optional courses. Four of the six elite schools conducted a total of ten lotteries in the five years covered by

contributions are around 300 euros per year for the elite schools in our study. This makes it unlikely that choices are restricted by financial motives.

[6]This was in 2015 replaced by the Deferred Acceptance mechanism.

[7]Schools could grant priority to siblings of current students, to children of staff members and to students from a primary school with a similar educational philosophy. Priority based on distance or prior achievement was explicitly not permitted. Schools had to announce their priority rules beforehand. It could happen that a school was oversubscribed for some tracks, but not for others. Within schools, lotteries were conducted for each track separately.

[8]Because a student's second or third preference may not be available in the second round, it may be optimal to apply in the first round to another school than the most-preferred school. The Boston mechanism is not strategy proof (e.g. Abdulkadiroğlu and Sönmez, 2003).

Table 1. Number of observations

Number of observations	Students	Schools	# Lotteries	Priority	Win	Lose
Pre-university students	4,664	31				
Applying to elite schools	3,003	6				
Applying to elite schools with lottery	2,296	4				
Applying to elite schools with lottery in lottery year	1,447	4	10	332	833	282

Note: This table reports the number of pre-university students applying to different schools offering the pre-university track. For the elite schools with lotteries it reports the total number of lotteries and the numbers of lottery winning, losing and priority students.

our data.[9]

3 Data

The data for this study come from two sources: the municipality of Amsterdam supplied register data on school applications and student achievement in primary school. The Dutch educational administration (DUO, Dienst Uitvoering Onderwijs) supplied data on student background characteristics, secondary school progress and exam performance. The two datasets are linked at the student level using a personal identifier.

Table 1 shows the number of students in the pre-university track and the numbers of students applying to elite schools. In the years that we study, 4,737 students were placed in the pre-university track and enrolled in a school in Amsterdam. We dropped 62 observations which could not be matched to education outcomes and 11 observations with missing information on key background variables. This resulted in a sample of 4,664 students.

Six of the 31 schools that offer the pre-university track are elite schools. Four elite schools conducted a total of ten admission lotteries in the five years covered by our data. None of the comprehensive schools conducted a lottery for its pre-university track in these years. Of the 1447 students who applied to an oversubscribed elite school, 332 were placed with priority and therefore exempted from the lottery.[10] This leaves us with a sample of 1115 lottery participants, of whom 833 won and 282 lost their lottery.[11] We visited the schools that conducted lotteries to confirm that they complied with the requirements of a fair lottery (were conducted after closure of the application window and executed by a notary). Section 4 presents results from balancing tests which support that the lotteries were conducted fairly.

[9] In the years that we consider, other schools conducted admission lotteries for their senior general secondary and vocational tracks. We do not analyze these lotteries here because these schools do not fit the label elite schools. Because lotteries were conducted for each track separately, these other lotteries do not interfere with our analyses.

[10] Table B1 in Appendix B indicates that students with priority are somewhat less likely to have a disadvantaged background than students who participated in the admission lotteries.

[11] To ensure the anonymity of schools we do not report the names of the schools that conducted lotteries, nor do we report student numbers at the level of separate schools.

From the data supplied by DUO on school progress and exam performance, we constructed four student achievement measures. First, an indicator that equals one for students who graduated from the pre-university track without delay, otherwise zero. Second, an indicator that equals one for students who graduated from the pre-university track with at most one year delay, otherwise zero.[12] Third, we create an indicator for the field of study that students specialize in during the last years in the pre-university track. The field of study strongly affects the options for tertiary education. As the science and health fields are considered the more difficult programs (Buser et al., 2014), and choosing these fields may affect whether a student graduates on time, we investigate whether placement in an elite schools affects the likelihood of choosing a science or health field. Fourth, we create a indicator that equals one for students who graduated from the pre-university track without delay with a GPA of at least 8 on a scale from 1 to 10 on the national exit exams, otherwise zero. A GPA of at least 8 is the typical requirement for graduation with distinction and places a student in the top decile of the GPA distribution at the pre-university level.

In addition to the student achievement measures, we constructed two outcome variables that capture students' school career. One variable is an indicator that equals one if the student was grade retained at least once, zero otherwise. The other variable is an indicator that equals one if the student changed schools while in secondary education.

Column (1) of Table 2 reports descriptive statistics of characteristics of students in the highest track who applied to a comprehensive school. Column (2) shows the difference in the mean values between students applying to comprehensive schools and students applying to elite schools, together with their standard errors. This shows that students applying to elite schools are less often from disadvantaged neighborhoods, less often have a non-western migrant background, were less often grade retained in primary school and less often come from one-parent families. The more advantageous background of students applying to elite schools is also expressed in the lower score for weighted student funding, which is an indicator for the extra funding primary schools receive for students from disadvantaged backgrounds. Students who apply to elite schools also have higher scores on the exit test from primary education, the Cito score, which we use as measure of baseline ability.[13] Most differences are quite sizable. The difference in Cito scores amounts to more than 25% of a standard deviation and the difference in the share of students with a non-western migrant background is 22 percentage points. Differences of similar magnitudes are found when students applying to comprehensive schools are compared to students applying to elite schools with a lottery (column (3)) and to students applying to an elite school with a lottery in a year with a lottery (column (4)).

[12] Students can obtain their pre-university diploma with one year delay after obtaining a senior general secondary (havo) diploma in year 5. These students are coded as obtaining their pre-university diploma with one year delay. This implies that there are two routes to obtaining a pre-university diploma with one year delay: being grade retained for one year, or finishing the pre-university track after the senior general secondary track.

[13] The nationwide exit test from primary school is developed and administered by an institute called Cito. The score is expressed on a scale from 500 to 550. Students who are placed in the pre-university track typically have a

Table 2. Difference in student characteristics between comprehensive and elite schools

Dependent variable	Mean (SD) for students applying to comprehensive schools (1)	Applying to elite school (2)	Applying to elite school with lottery (3)	Applying to elite school in year with lottery (4)
Boy	0.485	0.026*	0.022	0.025
	(0.500)	(0.015)	(0.016)	(0.018)
Disadvantaged	0.669	-0.169***	-0.160***	-0.165***
neighborhood	(0.471)	(0.015)	(0.016)	(0.017)
Non-western	0.391	-0.217***	-0.217***	-0.220***
migrant	(0.488)	(0.014)	(0.014)	(0.016)
Western	0.099	0.061***	0.052***	0.059***
migrant	(0.298)	(0.010)	(0.010)	(0.012)
Weighted student	0.258	-0.195***	-0.199***	-0.211***
funding	(0.437)	(0.012)	(0.012)	(0.012)
Cito score	543.06	1.954***	1.796***	2.505***
	(7.28)	(0.220)	(0.232)	(0.241)
Grade retained	0.019	-0.008**	-0.007*	-0.007
in primary ed	(0.137)	(0.004)	(0.004)	(0.004)
Grade skipped	0.018	0.011**	0.006	0.006
in primary ed	(0.133)	(0.004)	(0.005)	(0.005)
One parent family	0.053	-0.019***	-0.019***	-0.021***
	(0.224)	(0.006)	(0.007)	(0.007)
Number of students	1661	4664	3957	3108

Note: Column (1) reports the means and standard deviations for students in the pre-university track applying to comprehensive schools. For each of the dependent variables, column (2) reports separate regression coefficients on an indicator equal to 0 if a student applied to a comprehensive school, and 1 if a student applied to an elite school. In column (3), the indicator is 1 only for students applying to elite schools that conduct lotteries and in column (4) the indicator is 1 only for students that apply to elite schools with lotteries in years with school admission lotteries. Robust standard errors are reported in parentheses. ***p<0.01, **p<0.05, *p<0.10.

4 Empirical approach

To estimate the effects of elite schools on achievement we assume a linear relationship between the academic achievement of student i who participated in admission lottery l (Y_{il}) and initial enrollment in an elite school (ES_i):

$$Y_{il} = \delta ES_i + X_i'\beta + \nu_l + \varepsilon_{il} \tag{1}$$

where ν_l are lottery fixed effects, ε_{il} is a random error term and X_i is a vector of student-level covariates including the variables listed in Table 2 together with indicators for missing values for Cito score, weighted student funding and being grade retained in primary school. Covariates are included to gain precision, but we will also present results from specifications without covariates. δ is the parameter of interest.

Because some of the students who lose an admission lottery find a place in an elite school that did not conduct a lottery in that year, compliance with the results of the admission lottery is imperfect.[14] We therefore instrument ES_i with the result (0/1) of the admission lottery (LR_{il}) in which student i participated. We estimate a first-stage equation of the form:

$$ES_i = \lambda LR_{il} + X_i^{'}\pi + \upsilon_l + \epsilon_{il} \tag{2}$$

where υ_l are lottery fixed effects and ϵ_{il} is a random error component. Lottery fixed effects are included because lottery results are only random conditional on participation in the same lottery at the same school. λ is the first-stage effect and captures the share of compliers; this is the share of students in the sample for whom the result of the admission lottery determined whether they initially enrolled in an elite school or a comprehensive school.

Table 3 shows the first-stage results for the full sample and for different subsamples that we create to examine differential effects. Results are shown for specifications without (column (1)) and with (column (2)) control variables. The estimates confirm that the lottery is a relevant instrument: winning an admission lottery at an elite school increases the likelihood of initial enrollment in an elite school by 49 percentage points in the full sample. The effects are the same for boys and girls, somewhat larger for students with a non-western migrant background than for others, and 15 percentage points larger for students from the bottom half of the baseline ability distribution than for students from the top half.

Results from balancing tests are reported in Table 4. Columns (1) and (2) show the means and

score exceeding 545.

[14]In our data there is only one case of the other form of non-compliance; one lottery winner chose not to enroll in an elite school.

Table 3. First-stage results

	N	First stage (1)	F-value	First stage (2)	F-value
Full sample	1104	0.491***	25.12	0.491***	25.54
		(0.098)		(0.097)	
Lowest 50% Cito score	578	0.567***	27.32	0.568***	28.53
		(0.108)		(0.106)	
Highest 50% Cito score	512	0.419***	18.43	0.420***	18.86
		(0.098)		(0.097)	
Boys	562	0.489***	22.99	0.488***	22.91
		(0.102)		(0.102)	
Girls	542	0.493***	24.00	0.484***	23.77
		(0.101)		(0.099)	
Non-western migrant	208	0.524***	20.08	0.512***	19.29
		(0.117)		(0.117)	
Native or Western migrant	896	0.483***	23.08	0.482***	23.36
		(0.100)		(0.100)	
Controls				✓	

Note: Each row reports two sets of first stages and F-statistics of IV regressions with winning the school admission lottery as an instrument for initial enrollment in an elite school. The first row includes all students participating in the lotteries. The other rows display different subsamples used to investigate differential treatment effects. This table reports the first stages for obtaining the pre-university diploma on time, results are slightly different for outcome variables that are observed for fewer or more students. All regressions include lottery fixed effects. Controls include gender, living in a disadvantaged neighborhood, having a non-western or western migrant background, Cito score, missing Cito score, weighted student funding, missing information on weighted student funding, grade retention in primary education, skipping a grade in primary education, missing information on grade progression in primary education and living in a one parent family. Standard errors are clustered at the school of initial enrollment by cohort. ***p<0.01, **p<0.05, *p<0.10.

Table 4. Balancing results

Dependent variable	Mean (SD) lottery losers (1)	Mean (SD) lottery winners (2)	Balancing test lottery (3)	p-value (4)
Boy	0.479	0.519	0.032	0.366
	(0.500)	(0.500)	(0.035)	
Disadvantaged	0.553	0.531	-0.030	0.371
neighborhood	(0.498)	(0.499)	(0.034)	
Non-western	0.174	0.194	0.019	0.470
migrant	(0.380)	(0.396)	(0.026)	
Western	0.149	0.173	0.027	0.283
migrant	(0.357)	(0.378)	(0.025)	
Cito score	545.61	545.45	-0.207	0.609
	(6.78)	(6.10)	(0.404)	
Weighted student	0.067	0.052	-0.021	0.215
funding	(0.251)	(0.222)	(0.017)	
Grade retained	0.014	0.014	-0.002	0.769
in primary ed	(0.118)	(0.119)	(0.008)	
Grade skipped	0.021	0.025	0.002	0.840
in primary ed	(0.145)	(0.157)	(0.010)	
One parent family	0.046	0.034	-0.011	0.416
	(0.210)	(0.180)	(0.014)	
Number of students	282	833	1115	

Note: Columns (1) and (2) display the means and standard deviations for students losing and winning a school admission lottery. Columns (3) and (4) report separate regression coefficients and the p-values for regressing the dependent variables indicated in each row on an indicator variable equaling 0 if the student lost the lottery and equaling 1 if the student won the lottery. All regressions include lottery fixed effects. Robust standard errors are reported in parentheses.

standard deviations for students losing and winning an admission lottery. Columns (3) and (4) show the actual balancing tests, regressing an indicator for winning the lottery on the dependent variable denoted in each row. To account for differences between lotteries, all regressions include lottery fixed effects. The balancing tests do not reject that students who win and lose an admission lottery are the same in terms of observables. The null hypothesis of fair lotteries can also not be rejected when regressing the indicator for winning a lottery on all background characteristics jointly (p=0.6216).

A concern with our instrumental variable approach is that it assumes that the result of the lottery only affects student outcomes through placement in an elite school. This assumption is violated if students who lose the lottery and enroll in an elite school have different outcomes than they would have had in case of winning the lottery. In Section 6, we show that these losing always takers have better outcomes than winning compliers. While this does not prove that the exclusion restriction holds, it supports it.

5 Treatment characteristics

To examine what the treatment "initial enrollment in an elite school" entails, this section presents estimates of the effect of the treatment on i) measures of school quality as reported by the Dutch Inspectorate of Education and ii) peer characteristics.

Columns (2) and (3) of Table 5 report the average school characteristics for students winning and losing admission lotteries. Column (4) reports the results from IV estimates of the effects of initial enrollment in an elite school on school characteristics. The top panel of the table considers characteristics at the level of the school, while the bottom panel considers characteristics at the level of the pre-university track within the school (which is the same as the school level for elite schools).

The first three rows of the upper part, and the first two rows of the lower part of Table 5 report school quality indicators.[15] It turns out that enrollment in an elite school implies enrollment in a school with a significantly lower score on the index for grade progression in the first two years of the six year program. This is a measure of the percentage of students getting to the third grade without grade retention, correcting for students who attend higher or lower school tracks than their primary school advice. This result can either indicate that elite schools are of lower quality for the first three years, or could mean that elite schools are more strict with respect to grade progression in the lower grades. The other two quality measures pertain to the higher grades, and indicate higher school quality at elite schools. Enrollment in an elite school implies enrollment in a school with a higher percentage of students without delay in the higher grades and a school with students with higher average grades on the final exams.

The other school measures give a more detailed view on other school characteristics of elite schools. Enrollment in an elite school means a school with a higher percentage of academic (pre-university and senior general secondary) students in the higher grades and a higher percentage of students in one-track classes in the first year. Elite schools are somewhat, but not significantly, smaller than comprehensive schools where lottery losers enroll in. The percentage of students following the science and health fields is higher in schools attended by winning compliers than in schools attended by losing compliers. There is no significant difference in home to school distance between winning and losing compliers.

With respect to the characteristics of students' first year peers, Table 6 shows that enrollment in an elite school brings students a more advantaged peer group. Students in elite schools have fewer first-year peers from disadvantaged neighborhoods, from one-parent families and from a non-western migrant background. Further, the peers in elite schools achieve better academically. Their mean score on the exit test from primary school (Cito score) is higher, and winning compliers who

[15]The Dutch Inspectorate of Education publishes secondary school information on a yearly basis. For each student, the measures published in the year of school choice are used. The indicators pertaining to higher grades and final exams are published for each school track separately. For these variables, we report on the pre-university track and on an average weighted by the number of students in each school track.

Table 5. Effects of elite school enrollment on school characteristics

Dependent variable	N	Mean (SD) losing students	Mean (SD) winning students	IV estimates
	(1)	(2)	(3)	(4)
		All school tracks		
Index grade progression	840	105.480	98.147	-9.628***
lower grades		(9.333)	(2.415)	(3.094)
% no delay higher grades	840	64.682	72.501	6.260**
		(10.574)	(10.574)	(2.746)
Average grade on final exams	840	6.356	6.666	0.389***
		(0.339)	(0.286)	(0.060)
Number of students at entire school	840	930.539	874.867	-45.752
		(225.109)	(124.847)	(49.422)
% students in one-track classes	840	54.850	99.955	61.966***
in first year		(40.058)	(1.168)	(11.437)
% academic students in higher grades	840	90.991	99.916	11.835***
		(12.816)	(2.155)	(4.027)
% academic students with a	840	42.547	52.318	15.504***
science or health field		(11.777)	(4.599)	(2.284)
		Pre-university track		
% no delay higher grades	840	62.952	72.000	7.341*
		(14.738)	(11.465)	(3.779)
Average grade on final exams	840	6.347	6.659	0.373***
		(0.349)	(0.292)	(0.063)
% pre-uni students in higher grades	840	61.534	91.763	37.687***
		(23.948)	(13.506)	(5.277)
% pre-uni students with a	840	47.624	53.586	11.912***
science or health field		(11.122)	(4.422)	(2.583)
Distance to school in kilometers	1115	3.123	3.167	0.094
		(2.006)	(2.169)	(0.315)

Note: Each row reports an IV regressions with winning the school admission lottery as an instrument for initial enrollment in an elite school. The first column reports the number of students in the regression, the second and third mention the means and standard deviations for losing and winning students. The last column reports the regression coefficients and standard errors of the IV regression. The numbers of students in the regressions differ since not all indicators are available for all years and schools. All regressions include lottery fixed effects and controls. Controls are listed below Table 3. Standard errors are clustered at the school of placement by cohort. ***p<0.01, **p<0.05, *p<0.10.

Table 6. Effects of elite school enrollment on peer composition; all tracks

Dependent variable	N	Mean (SD) losing students	Mean (SD) winning students	IV estimates
Mean Cito score	989	542.37	545.38	4.937***
		(3.99)	(2.80)	(0.539)
Rank Cito score	975	0.624	0.437	-0.317***
		(0.299)	(0.257)	(0.030)
% of primary school peers	983	0.072	0.079	0.008
		(0.088)	(0.087)	(0.017)
Cohort size	989	164.40	139.36	-41.962***
		(57.89)	(16.54)	(13.811)
% Boys	989	0.525	0.523	-0.005
		(0.064)	(0.045)	(0.023)
% Disadvantaged neighborhood	989	0.561	0.445	-0.216***
		(0.152)	(0.144)	(0.059)
% Non-western migrant	989	0.305	0.168	-0.247***
		(0.159)	(0.029)	(0.034)
% Western migrant	989	0.121	0.155	0.062***
		(0.034)	(0.030)	(0.021)
% Weighted student funding	989	0.154	0.041	-0.198***
		(0.114)	(0.019)	(0.032)
% Grade retained in primary ed	989	0.034	0.013	-0.041***
		(0.030)	(0.009)	(0.005)
% Grade skipped in primary ed	989	0.019	0.027	0.015**
		(0.018)	(0.014)	(0.006)
% One parent family	989	0.057	0.028	-0.051***
		(0.036)	(0.013)	(0.009)

Note: See Table 5.

enroll in elite schools have on average a lower rank in the test score distribution of their peers than the losing compliers who enroll in a comprehensive school. Table B2 in Appendix B shows that these differences not only hold at the school level but also at the track level. Students enrolling in elite schools have a higher percentage peers in the pre-university track who attended the same primary school.

To summarize, students who enroll in an elite school after winning a school admission lottery attend schools with more affluent peers in terms of prior academic achievement and social background than students who attend a comprehensive school after losing an admission lottery. Regarding school quality as measured by the Dutch Inspectorate of Education, the picture is mixed. Elite schools perform worse on the measure of grade progression in the lower grades but better on progression in the upper grades and on exam grades.

Table 7. Effects of elite schools on student achievement

Outcome	N	CCM	(1)	(2)
Pre-university diploma on time	1104	0.646	-0.134**	-0.125**
			(0.063)	(0.058)
Pre-university diploma with at most one year delay	1104	0.820	-0.085*	-0.078*
			(0.048)	(0.045)
Pre-university diploma with GPA $\geq$ 8	1104	0.015	0.049**	0.058**
			(0.025)	(0.025)
Science or health fields	1090	0.513	-0.027	-0.031
			(0.060)	(0.057)
Grade retention	1105	0.291	0.130**	0.120**
			(0.051)	(0.048)
Changed school during secondary education	1115	0.239	-0.021	-0.029
			(0.057)	(0.061)
Controls				✓

Note: Each row reports two IV regressions with winning the school admission lottery as an instrument for initial enrollment in an elite school. The first column reports the number of students in the regressions, the second column reports the control complier mean. Models (1) and (2) report IV estimates without and with controls. All regressions include lottery fixed effects. Controls are listed below Table 3. Standard errors are clustered at the school of placement by cohort. ***p<0.01, **p<0.05, *p<0.10.

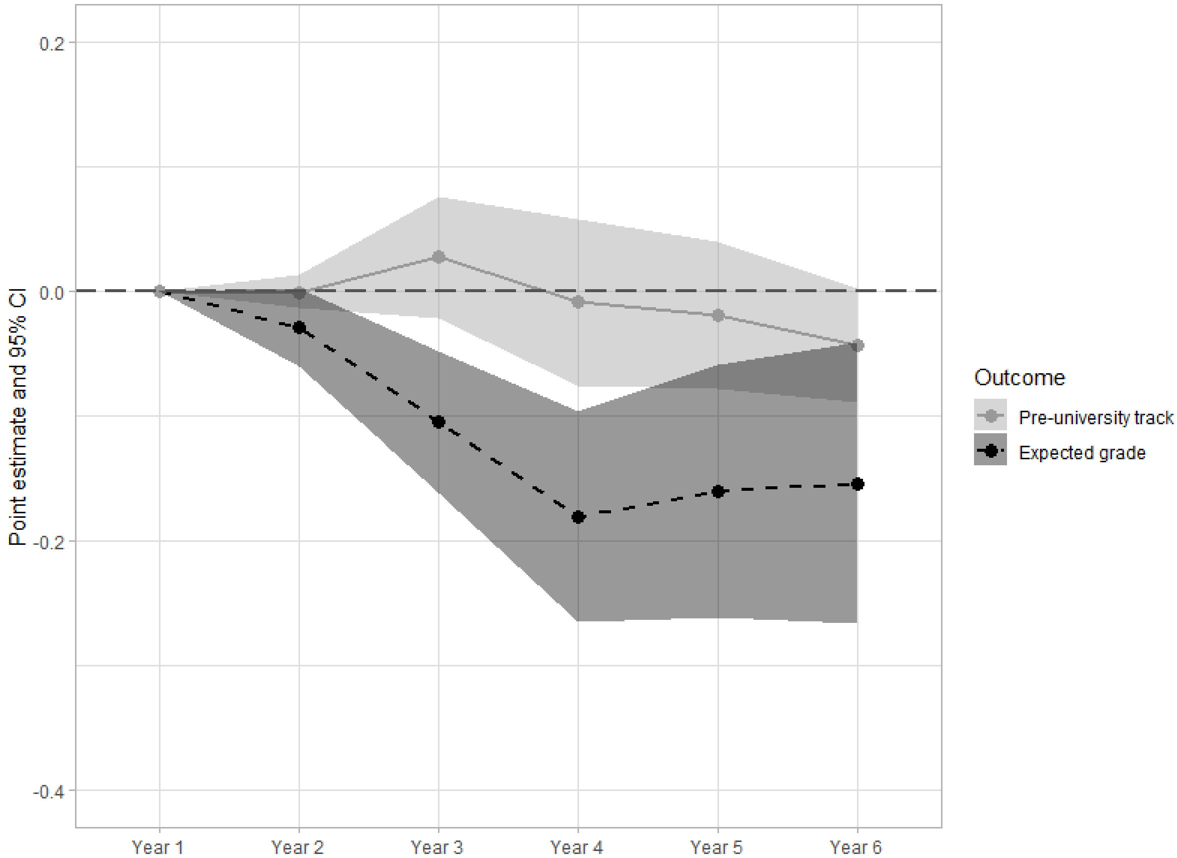
6 Results

We present the results in four parts. We start with estimates based on the full sample of lottery participants. Next we examine heterogeneity of the effects of elite schools by students' baseline ability and their gender. In the third part we compare the estimates based on admission lotteries with estimates in the spirit of value-added models in which we condition on baseline ability and rich background information. In the final part, we discuss results from various robustness analyses.

Full sample. Table 7 reports IV estimates of the effects of enrollment in elite schools for the full sample of lottery participants. The first row shows that enrollment in an elite school reduces the probability to obtain the pre-university diploma on time by around 13 percentage points, and the probability to obtain that diploma with at most one year delay by around 8 percentage points. These negative effects are quite substantial compared to the respective control complier means of 0.65 and 0.82. Consistent with this, we see that enrollment in an elite school leads to a higher probability of grade retention. At the same time, we find a positive effect of enrollment in an elite school on the probability to obtain the pre-university diploma on time with a GPA of at least 8.0 on a scale from 1 to 10. In the full sample, enrollment in an elite school has no significant effects on specializing in the science and health fields or on changing school during secondary education.

When students do not obtain their pre-university diploma on time, this can either mean that they are grade retained or that they switched to a lower track. Figure 2 shows IV estimates of the impact of elite schools on students' year-to-year progression in secondary education. This reveals

Figure 2. Impact of elite school attendance on secondary school progress



Note: Each dot reports the result of an IV regression with winning the school admission lottery as an instrument for initial enrollment in an elite school. The outcomes are whether students are in the pre-university track and in the expected grade at the start of a school year. In the first three years, the track is not always precisely registered in comprehensive schools. In these cases, we assume that students are in the pre-university track. All regressions include lottery fixed effects and controls. Controls are listed below Table 3. Shaded areas indicate 95% confidence intervals based on standard errors that are clustered at the school of placement by cohort.

that the negative effects of elite schools mainly arise through an increase in grade retention in the first years of secondary education, which then levels off in the higher grades. At the start of the sixth year, however, we also see that students who initially enrolled in an elite school are significantly less often in the pre-university track.

Heterogeneous effects. The combination of negative and positive effects in Table 7 suggests that some students are harmed by enrollment in an elite school while others benefit from it. We examine heterogeneous effects along two dimensions: baseline ability and gender.

As measure of baseline ability we use students' score on the exit test from primary school (Cito score) and split the sample by having a score above or below the median.[16] We repeat the previous

[16]An alternative approach is to interact the treatment variable with the continuous score. This approach does not work well because the Cito score is top-coded at the maximum of 550 for almost 25% of our sample. This does not mean that almost 25% of the sample makes no single mistake on the test. There is still variation in the results

analyses for the two subsamples separately. Column (1) of Table 8 repeats the results from Table 7 where we drop the 14 observations for which the score on the exit test from primary school is not available. Columns (2) and (3) report the results for the samples below and above the median. This reveals that the negative effect on obtaining the pre-university diploma on time is completely due to students from the bottom part of the ability distribution. The positive effect on obtaining the pre-university diploma with a GPA of at least 8.0 is, on the other hand, entirely due to students from the upper part. The negative overall impact on obtaining the pre-university diploma with at most one year delay is not concentrated in one of the two ability groups. Elite school enrollment increases the probability to change schools during secondary education for students from the lower half of the ability distribution, whereas it decreases the probability to change schools for students from the upper half.

Columns (4) and (5) report results separately for boys and girls. These results show that the negative overall effects on obtaining the pre-university diploma on time or with at most one year delay are entirely due to boys and that the positive effect on obtaining the pre-university diploma with a GPA of at least 8.0 is completely due to girls. Moreover, it turns out that enrollment in an elite school reduces the probability that girls specialize in the science or health fields by 12 percentage points. This is a large effect considering that 54% percent of the girls chooses one of these fields.

The findings in columns (2) to (5) warrant an analysis by combined baseline ability and gender groups. We therefore split the sample into four subsamples: boys below the median, girls below the median, boys above the median and girls above the median. The sizes of these subsamples are between 250 and 300 observations per subsample, which reduces the precision. Nevertheless, the results in columns (6) to (9) reveal some clear patterns. First, the negative effect on obtaining the pre-university diploma with at most one year delay is due to boys from both parts of the ability distribution. Second, the positive effect on obtaining the pre-university diploma on time with a GPA of at least 8.0 is due girls but also boys from the upper part of the ability distribution. Finally, the negative effect for girls to choose the science or health fields is due to girls from the lower part of the ability distribution. Girls from the upper part of the ability distribution are unaffected.[17]

Comparison with value-added estimates. School effect estimates based on admission lotteries provide an opportunity to validate more common value-added estimates of school quality. To do so, we estimated OLS regressions of school outcomes on a dummy variable for enrollment in an elite school controlling for the rich set of background information, including baseline ability. These regressions are in the spirit of value-added models which assume that assignment to schools

of students with the maximum score but this variation is not reported in the data.

[17] We have also inquired whether elite schools have differential effects by ethnicity. Table B3 in Appendix B shows that effects are quite similar for students with a non-western migrant background and for other students.

Table 8. Effects of elite schools on student achievement for different subgroups

Outcome	Full sample	Lowest 50%	Highest 50%	Boys	Girls	Lowest 50% Boys	Lowest 50% Girls	Highest 50% Boys	Highest 50% Girls
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Diploma on time	-0.114*	-0.221***	0.066	-0.313***	0.051	-0.364***	-0.077	-0.083	0.178
	(0.059)	(0.073)	(0.090)	(0.102)	(0.071)	(0.122)	(0.100)	(0.166)	(0.114)
Diploma at most 1 yr delay	-0.064	-0.064	-0.048	-0.250***	0.108	-0.196***	0.077	-0.282**	0.090
	(0.045)	(0.061)	(0.071)	(0.068)	(0.066)	(0.069)	(0.100)	(0.118)	(0.093)
Diploma with GPA ≥ 8	0.062**	-0.009	0.171***	0.006	0.099***	-0.046	0.034	0.203**	0.185***
	(0.025)	(0.024)	(0.050)	(0.040)	(0.036)	(0.046)	(0.030)	(0.087)	(0.058)
Science or health field	-0.020	-0.070	0.072	0.056	-0.118*	0.001	-0.173*	0.174	-0.034
	(0.056)	(0.073)	(0.115)	(0.086)	(0.068)	(0.106)	(0.090)	(0.213)	(0.125)
Grade retention	0.112**	0.190***	-0.035	0.237***	0.019	0.262**	0.145	0.050	-0.112
	(0.050)	(0.067)	(0.075)	(0.089)	(0.065)	(0.111)	(0.104)	(0.154)	(0.089)
Changed school	-0.040	0.136***	-0.309***	0.046	-0.110	0.179**	0.128	-0.261	-0.334***
	(0.063)	(0.049)	(0.113)	(0.064)	(0.088)	(0.076)	(0.103)	(0.196)	(0.116)
N	1090	578	512	553	537	299	279	254	258

Note: Each estimate comes from a separate IV regression with winning the admission lottery as instrument for initial enrollment in an elite school. Relevant (sub)sample is indicated in the column entries, numbers of observations are reported in bottom row. 14 students with missing Cito scores are omitted from the sample. All regressions include lottery fixed effects and controls. Controls are listed below Table 3. Standard errors are clustered at the school of placement by cohort. ***$p<0.01$, **$p<0.05$, *$p<0.10$.

(or teachers) is random conditional on control variables. Results are reported in Table 9.

The first two columns are based on the entire sample of students who enrolled in the highest track in a secondary school in Amsterdam in the period 2007-2010.[18] The results in column (1) are from a regression without any control variable, the results in column (2) from one that includes the full set of control variables. The results in column (2) are very different from the lottery-based results in Table 7. While the value-added estimates suggest that enrollment in an elite school increases the probability to obtain the pre-university diploma and to choose the science or health fields and has no impact on grade retention, the lottery-based estimates point in the opposite direction. The value-added and lottery-based results only concur for the probability to obtain the pre-university diploma with a GPA of at least 8.0.

Columns (3) to (6) repeat columns (1) and (2) but for restricted samples that more closely resemble the schools included in the lottery-based estimates. Columns (3) and (4) restrict the sample to elite schools that conducted admission lotteries and to comprehensive schools that placed students who participated in the admission lotteries for elite schools. Columns (5) and (6) use the same sample as columns (3) and (4) but weigh students' schools proportional to the shares of the lottery participants they placed. While these adjustments change the value-added estimates somewhat, they remain very different from the lottery-based estimates. Hence, in the context of elite schools in Amsterdam, value-added estimates are severely biased despite the inclusion of detailed background data.

To understand the sources of selection bias in the value-added estimates, Table B4 in Appendix B reports mean outcomes (not effects) for different groups of treated and untreated students. This shows that students in elite schools who are not included in the IV-estimates (always takers and students placed with priority) have better outcomes than students in elite schools who are included in these estimates (winning compliers).[19] Likewise, students in comprehensive schools who are not included in the IV estimates (students in comprehensive schools who did not participate in a lottery) have worse outcomes than students in comprehensive schools who are included in these estimates (losing compliers).

Robustness. Four of the six elite schools in Amsterdam conducted admission lotteries in the years that we consider. To assess whether the results are driven by one school in particular, we repeated the foregoing analyses four times, each time leaving out one of the four schools. The point estimates do not change much when leaving one of the schools out and leave the qualitative results intact. We are not allowed to report these results in a table or graph because this makes it

[18]This table does not include students starting secondary education in 2006. For this year, we do not have data available for students at comprehensive schools who did not participate in lotteries.

[19]The outcomes for always takers are observed as the outcomes of students who lost the lottery but yet enrolled in an elite school. Since these students generally enroll in another elite school than the one they lost the lottery for, one might be concerned that this has a negative impact on their outcomes, thereby violating the exclusion restriction. The fact that the losing always takers have better outcomes than the winning compliers supports – but does not prove – this restriction.

Table 9. Value added estimates of elite schools relative to comprehensive schools

Outcome	Elite schools vs. all comprehensive schools with pre-university students		Elite schools with lotteries vs. comprehensive schools with lottery losing students		Elite schools with lotteries vs. comprehensive schools with lottery losing students weighted with shares of lottery participants	
	(1)	(2)	(3)	(4)	(5)	(6)
Diploma on time	0.134***	0.084***	0.132***	0.078***	0.108***	0.068**
	(0.023)	(0.021)	(0.026)	(0.025)	(0.030)	(0.030)
Diploma at most 1 yr delay	0.179***	0.129***	0.178***	0.122***	0.152***	0.113***
	(0.019)	(0.017)	(0.022)	(0.021)	(0.026)	(0.027)
Diploma with GPA ≥ 8	0.057***	0.049***	0.057***	0.047***	0.053***	0.043***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.010)	(0.011)
Science or health field	0.073***	0.066***	0.068***	0.063***	0.046*	0.044
	(0.020)	(0.020)	(0.023)	(0.024)	(0.026)	(0.029)
Grade retention	-0.054**	-0.007	-0.068***	-0.014	-0.048*	-0.004
	(0.021)	(0.020)	(0.024)	(0.024)	(0.029)	(0.030)
Changed school	0.015	0.037**	-0.005	0.012	-0.017	0.011
	(0.017)	(0.017)	(0.019)	(0.021)	(0.026)	(0.027)
N	4423	4423	3092	3092	3092	3092
Controls		✓		✓		✓

Note: Each estimate comes from a separate OLS regression of the outcome indicated in the row entry on a dummy variable for initial enrollment in an elite school. Columns (1), (3) and (5) include no further control variables, columns (2), (4) and (6) include the control variables listed below Table 3. Columns (1) and (2) are based on all students that enrolled in the pre-university track in the same years as the students who participated in the admission lotteries; columns (3) and (4) are restricted to students that were enrolled in elite schools that had lotteries and comprehensive schools that received lottery losers; columns (5) and (6) weigh students by the share of lottery participants that were placed in the school. Standard errors are clustered at the school of placement by cohort. ***p<0.01, **p<0.05, *p<0.10.

possible to infer results for individual schools.

We chose the threshold of 8.0 for high GPA's because this is often required for graduation with distinction ("*cum laude*"). Appendix Tables B5 and B6 report results for other thresholds. Results are similar when a threshold of 8.5 is chosen. Coefficients are similar, but less precise, for thresholds at 7.5 and 7. We have also examined whether the results on obtaining the diploma with a high GPA are driven by grades for Latin or old Greek. The results in Table B7 show that this is not the case.

The value-added results reported in Table 9 control linearly for the Cito score. Table B8 reports results from specifications that include second order and third order polynomials. This results in value-added estimates closer to zero and some are no longer significantly different from zero. The results are, however, still very different from the effect estimates based on the admission lotteries.

7 Conclusions

We have used data from admission lotteries for elite schools in Amsterdam to show that effects of enrollment in an elite school instead of a comprehensive school are heterogeneous by baseline ability. For students from the top half of the baseline ability distribution, enrollment in an elite school increases the probability to graduate on time from the highest track with a high GPA. For students from the lower half of the distribution, elite school enrollment lowers the probability to graduate from the highest track on time.

The effects of enrollment in an elite school are also heterogeneous by gender. For boys from the bottom part of the (qualifying) baseline ability distribution, enrollment in an elite school makes it less likely to obtain the pre-university diploma with at most one year delay. Girls from this part of the distribution are less likely to opt for the more prestigious science or health fields if enrolled in an elite school. Girls from the upper half of the ability distribution benefit from enrollment in elite schools; they are more likely to obtain the pre-university diploma with a GPA of at least 8.0. For boys from the upper half of the ability distribution, results are mixed. For some, enrollment in an elite school reduces the probability to obtain the pre-university diploma with at most one year delay. For others, it increases the probability to obtain the pre-university diploma on time with a GPA of at least 8.0.

Our findings can explain why the results from previous studies are mixed. These studies typically conclude that the effects of elite schools in their setting have a specific sign; positive, or zero, or negative. Most of these studies use a regression discontinuity design thereby identifying effects for students from a narrow interval of the ability distribution. If in our setting admission would have been based on qualifying scores instead of lotteries, we would have found negative or positive effects depending on the location of the admission threshold in the baseline testscore distribution.

Our study design is silent about the causes of the heterogeneous effects. A possible explanation is that teachers in elite schools target their teaching to the better students in their classes. The increase in the share of students who obtain their diploma on time with a high GPA is consistent with this (e.g. Duflo et al., 2011). Another possible explanation is that having lower baseline ability than one's peers may negatively affect a student's confidence and thereby harm school achievement (e.g. Murphy and Weinhardt, 2013). Classmates in elite schools come from more affluent social backgrounds and score higher on baseline ability measures than classmates in comprehensive schools.

We have also compared our results based on admission lotteries with estimates in the spirit of value-added models that control for a rich set of background characteristics including school performance at baseline. This comparison shows that in our setting value-added estimates are severely biased in the direction of showing favorable effects of elite schools. Further analysis reveals that this is due to winning compliers having worse outcomes than always takers and students who are placed in an elite school with priority, as well as to losing compliers having better outcomes than students in comprehensive schools who did not participate in the admission lotteries for elite schools.

While there is no tradition in the Netherlands to provide information on value-added estimates to parents, it is likely that parents' perceptions of school quality are based on similar information (graduation rates and GPA on exit exams). This may explain why students who would be better off in a comprehensive school choose to enroll in an elite school. That a substantial share of these students later change to another school, suggests that they regret their initial choices (cf. Narita, 2018). Information about the differential effects of elite schools for different groups of students could help students to choose a school that is a good match for them. This would also free up places at oversubscribed elite schools for students for whom these schools are beneficial and who may otherwise lose a lottery.

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A Overview of previous studies

Table A1. Overview of previous studies

Study	Setting	Method	Results	Heterogeneity by ability
Cullen et al. (2006)	US; HS	Admission lotteries	Winners attend better schools and have better peers No impact on school outcomes	Marginally negative impact for students with below average 8th grade test scores
Hastings and Weinstein (2008)	US; HS	Information as IV	Attending higher performing school increases test scores	Not reported
Jackson (2010)	TT; SS	RD	Positive effects, especially for girls	Not reported
Clark (2010)	UK; HS	RD	Selective school students have better peers At best small effects on test scores Positive effect on university enrollment	Not reported
Dobbie and Fryer (2011)	US; MS	Admission lotteries Zone*cohort as IV	Positive effects, especially on math scores	No differential effects by baseline ability
Pop-Eleches and Urquiola (2013)	RO; HS	RD	Positive effects	Effects are larger at higher admission thresholds
Abdulkadiroğlu et al. (2014)	US; ES	RD	Students above admission thresholds have better peers Little effect on test score or college quality	No differential effects by baseline ability
Lucas and Mbiti (2014)	KE; SS	RD	Little evidence of positive impacts on learning outcomes	No differential effects by baseline ability
Beuermann and Jackson (2018)	BB; SS	RD	No effects on short-run test scores Positive effects for girls on various long-run outcomes Results for boys are mixed	Not reported
Abdulkadiroğlu et al. (2018)	US; K-12	Voucher lottery as IV	Negative effects on student outcomes from attending private school	Not reported
Wu et al. (2019)	CN; HS	RD	Elite schools have no impact on exam scores Magnet classes have positive impact on exam scores	Not reported
Barrow et al. (2020)	US; HS	RD	Selective high schools do not raise test scores overall, negative effects for students from low SES neighborhoods	Not reported

Note: Column (2) reports the country and education level of the study. BB for Barbados, CN for People's Republic of China, KE for Kenya, RO for Romania, TT for Trinidad and Tobago, US for United States. HS for high school, SS for secondary school, MS for middle school, ES for exam school. Column (3) indicates the source of identifying variation; RD stands for regression discontinuity design.

B Additional tables

This appendix includes additional tables.

Table B1 reports descriptive statistics of student characteristics separately for student participating in admission lotteries for elite schools and students placed in these schools with priority. It shows that students placed with priority come from more affluent backgrounds than other applicants to elite schools.

Table B2 reports IV estimates of the effects of enrollment in elite schools on peer characteristics at the pre-university track level.

Table B3 reports IV estimates of the effects of enrollment in elite schools on outcomes separately for students with a non-western migration background versus native students together with students with a western migration background. We can typically not reject that effects are the same for both groups.

Table B4 reports mean outcomes (not effects) for different groups of treated and untreated students. Column (1) pertains to lottery participants who enrolled in an elite school because they won a lottery (treated compliers). Column (2) pertains to lottery participants who enrolled in an elite school irrespective of the lottery result (always takers). Column (3) reports mean outcomes for students who enrolled in an elite school on the basis of priority and therefore did not participate in a lottery. Column (4) pertains to lottery participants who enrolled in a comprehensive school because they lost a lottery (untreated compliers). Finally, column (5) reports mean outcomes for students who did not participate in an admission lottery for an elite school and enrolled in a comprehensive school.

Tables B5 and B6 show results for the effect of enrollment in an elite school on obtaining the pre-university diploma on time with a GPA above certain thresholds.

Table B7 shows results for the effect of enrollment on obtaining the diploma on time with a high GPA, where GPA excludes scores for Latin and Old Greek.

Table B8 presents results from the value added approach for different polynomials of baseline ability (Cito score).

Table B1. Differences in background characteristics between students participating in the lottery and students being placed with priority

Dependent variable	Mean (SD) for students with priority (1)	Mean (SD) for students without priority (2)	Difference (3)	P-values (4)
Boy	0.515	0.509	0.004	0.889
	(0.501)	(0.500)	(0.032)	
Disadvantaged neighborhood	0.398	0.536	0.116	0.000
	(0.490)	(0.499)	(0.030)	
Non-western migrant	0.108	0.189	0.081	0.000
	(0.311)	(0.392)	(0.021)	
Western migrant	0.127	0.167	0.046	0.036
	(0.333)	(0.373)	(0.022)	
Cito score	545.81	545.50	0.252	0.443
	(5.79)	(6.27)	(0.328)	
Weighted student funding	0.018	0.056	0.032	0.002
	(0.133)	(0.229)	(0.010)	
Grade retained in primary ed	0.006	0.014	0.009	0.115
	(0.077)	(0.119)	(0.006)	
Grade skipped in primary ed	0.024	0.024	-0.002	0.808
	(0.154)	(0.154)	(0.010)	
One parent family	0.015	0.037	0.021	0.019
	(0.122)	(0.188)	(0.009)	
Number of students	332	1115		

Note: Columns (1) and (2) display the means and standard deviations for students who got placed with priority and for students without priority who participated in the lottery. Columns (3) and (4) report separate regression coefficients and the p-values of the dependent variables indicated in each row on an indicator variable equaling 0 if the student was placed with priority and equaling 1 if the student participated in the lottery. All regressions include lottery fixed effects. Robust standard errors are reported in parentheses.

Table B2. Effects of elite school enrollment on peer composition; pre-university track

Dependent variable	N	Mean (SD) losing students	Mean (SD) winning students	IV estimates
Mean Cito score	989	544.54	545.40	1.095**
		(3.11)	(2.79)	(0.486)
Rank Cito score	975	0.505	0.437	-0.112***
		(0.276)	(0.257)	(0.025)
% of primary school peers	960	0.093	0.198	0.184***
		(0.147)	(0.176)	(0.032)
Cohort size	989	77.42	138.72	110.027***
		(40.64)	(15.75)	(7.792)
% Boys	989	0.518	0.524	0.009
		(0.079)	(0.045)	(0.025)
% Disadvantaged neighborhood	989	0.546	0.445	-0.188***
		(0.167)	(0.144)	(0.062)
% Non-western migrant	989	0.254	0.168	-0.155***
		(0.127)	(0.029)	(0.033)
% Western migrant	989	0.123	0.156	0.060**
		(0.048)	(0.030)	(0.025)
% Weighted student funding	989	0.136	0.042	-0.167***
		(0.122)	(0.019)	(0.037)
% Grade retained in primary ed	989	0.006	0.012	0.008**
		(0.011)	(0.007)	(0.004)
% Grade skipped in primary ed	989	0.030	0.027	-0.005
		(0.022)	(0.014)	(0.009)
% One parent family	989	0.039	0.029	-0.018**
		(0.026)	(0.013)	(0.008)

Note: See Table 5.

Table B3. Impact of attending an elite school by ethnicity

Outcome	Non-western migrant background	Native or western migrant background
Pre-university diploma on time	-0.154	-0.129**
	(0.126)	(0.065)
Pre-university diploma with at most one year delay	-0.022	-0.096**
	(0.144)	(0.045)
Pre-university diploma with GPA $\geq$ 8	0.073*	0.055*
	(0.039)	(0.029)
Science or health fields	0.101	-0.066
	(0.171)	(0.061)
Grade retention	0.143	0.123**
	(0.142)	(0.051)
Changed school during secondary education	0.172**	-0.067
	(0.075)	(0.068)
N	208	896

Note: Each estimate comes from a separate IV regression with winning the admission lottery as instrument for initial enrollment in an elite school. Relevant subsample is indicated in the column entries, numbers of observations reported in bottom row. All regressions include lottery fixed effects and the control variables listed below Table 3. Standard errors are clustered at the school of placement by cohort. ***p<0.01, **p<0.05, *p<0.10.

Table B4. Comparing outcomes between different groups

	With elite school			Without elite school		p-values		
	Compliers	Always takers	Placed with priority	Compliers	Non-participants	(2) vs (1)	(3) vs (1)	(4) vs (5)
Outcome	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Diploma on time	0.505	0.741	0.670	0.644	0.502	0.000	0.000	0.002
		(0.036)	(0.026)	(0.042)	(0.012)			
Diploma at most 1 yr delay	0.736	0.878	0.827	0.818	0.635	0.000	0.000	0.000
		(0.027)	(0.021)	(0.034)	(0.012)			
Diploma with GPA ≥ 8	0.050	0.102	0.067	0.015	0.021	0.041	0.239	0.627
		(0.025)	(0.014)	(0.011)	(0.004)			
Science or health field	0.497	0.582	0.561	0.511	0.468	0.039	0.020	0.336
		(0.041)	(0.028)	(0.044)	(0.013)			
Grade retention	0.427	0.245	0.292	0.293	0.384	0.000	0.000	0.039
		(0.036)	(0.025)	(0.040)	(0.012)			
Changed school	0.224	0.196	0.175	0.239	0.191	0.397	0.019	0.177
		(0.033)	(0.021)	(0.037)	(0.010)			
N	383-395	146-148	326-332	131-134	1582-1661			

Note: Each cell in columns (1) to (5) reports a mean outcome for the group indicated by column entry. The mean outcome with treatment for compliers is computed using the approach of Imbens and Rubin (1997) based on IV regressions. Columns (6) to (8) report p-values for significance of the differences between the means of the row groups indicated by the column entry. (6) and (7) use one-sample t-tests comparing (2) and (3) to (1), (8) uses independent two-sample t-tests comparing (4) to (5)

Table B5. Effects of elite schools on obtaining pre-university diploma on time with GPA above different thresholds

	N	CCM	(1)	(2)
Pre-university diploma with GPA ≥ 8	1104	0.015	0.049**	0.058**
			(0.025)	(0.025)
Pre-university diploma with GPA ≥ 8.5	1104	0.008	0.029**	0.029**
			(0.012)	(0.013)
Pre-university diploma with GPA ≥ 7.5	1104	0.084	0.052	0.064
			(0.040)	(0.039)
Pre-university diploma with GPA ≥ 7	1104	0.213	0.034	0.051
			(0.056)	(0.054)

Note: Each row reports two IV regressions with winning the school admission lottery as an instrument for initial enrollment in an elite school. The first column reports the number of students in the regressions, the second column reports the mean and standard deviation. Models (1) and (2) report IV estimates without and with controls. All regressions include lottery fixed effects. Controls are listed below Table 3. Standard errors are clustered at the school of placement by cohort. ***p<0.01, **p<0.05, *p<0.10.

Table B6. Alternative specifications for GPA for different subgroups

Outcome	Full sample	Lowest 50%	Highest 50%	Boys	Girls	Lowest 50% Boys	Lowest 50% Girls	Highest 50% Boys	Highest 50% Girls
Pre-university diploma with GPA ≥ 8	0.062**	-0.009	0.171***	0.006	0.099***	-0.046	0.034	0.203**	0.185***
	(0.025)	(0.024)	(0.050)	(0.040)	(0.036)	(0.046)	(0.030)	(0.087)	(0.058)
Pre-university diploma with GPA ≥ 8.5	0.027**	-0.012	0.084***	0.010	0.032*	-0.031	-0.000	0.145**	0.072*
	(0.012)	(0.015)	(0.026)	(0.028)	(0.017)	(0.032)	(0.008)	(0.070)	(0.039)
Pre-university diploma with GPA ≥ 7.5	0.068*	-0.063	0.260***	-0.040	0.160**	-0.096	-0.040	0.161	0.363***
	(0.039)	(0.054)	(0.075)	(0.058)	(0.065)	(0.068)	(0.078)	(0.104)	(0.113)
Pre-university diploma with GPA ≥ 7	0.051	-0.003	0.126	0.030	0.063	-0.057	0.031	0.294**	0.075
	(0.056)	(0.061)	(0.114)	(0.064)	(0.092)	(0.089)	(0.105)	(0.147)	(0.167)
	1090	578	512	553	537	299	279	254	258

Note: Each estimate comes from a separate IV regression with winning the admission lottery as instrument for initial enrollment in an elite school. Relevant (sub)sample is indicated in the column entries, numbers of observations reported in bottom row. 14 students with missing Cito scores are omitted from the sample. All regressions include lottery fixed effects and the controls listed below Table 3. . Standard errors are clustered at the school of placement by cohort. ***p<0.01, **p<0.05, *p<0.10.

Table B7. Effects of elite schools on obtaining diploma with high GPA, omitting Latin and Old Greek

Outcome	Full sample (1)	Lowest 50% (2)	Highest 50% (3)	Boys (4)	Girls (5)	Lowest 50% Boys (6)	Lowest 50% Girls (7)	Highest 50% Boys (8)	Highest 50% Girls (9)
Pre-university diploma with GPA $\geq$ 8	0.062**	-0.009	0.171***	0.006	0.099***	-0.046	0.034	0.203**	0.185***
GPA based on all subjects	(0.025)	(0.024)	(0.050)	(0.040)	(0.036)	(0.046)	(0.030)	(0.087)	(0.058)
Pre-university diploma with GPA $\geq$ 8	0.087***	-0.004	0.227***	0.075*	0.088**	-0.017	0.016	0.339***	0.180***
GPA excluding Latin and Old Greek	(0.028)	(0.024)	(0.061)	(0.043)	(0.036)	(0.040)	(0.029)	(0.129)	(0.059)
	1090	578	512	553	537	299	279	254	258

Note: Each estimate comes from a separate IV regression with winning the admission lottery as instrument for initial enrollment in an elite school. Relevant (sub)sample is indicated in the column entries, numbers of observations reported in bottom row. 14 students with missing Cito scores are omitted from the sample. All regressions include lottery fixed effects and the controls listed below Table 3. Standard errors are clustered at the school of placement by cohort. ***p<0.01, **p<0.05, *p<0.10.

Table B8. Value added estimates including polynomials of Cito score

Outcome	Elite schools vs. all comprehensive schools with pre-university students			Elite schools with lotteries vs. comprehensive schools with lottery losing students			Elite schools with lotteries vs. comprehensive schools with lottery losing students weighted with shares of lottery participants		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Diploma on time	0.084***	0.061***	0.046**	0.078***	0.055**	0.039	0.068**	0.048*	0.034
	(0.021)	(0.021)	(0.020)	(0.025)	(0.025)	(0.025)	(0.030)	(0.028)	(0.028)
Diploma at most 1 yr delay	0.129***	0.112***	0.103***	0.122***	0.107***	0.097***	0.113***	0.105***	0.096***
	(0.017)	(0.017)	(0.016)	(0.021)	(0.020)	(0.020)	(0.027)	(0.027)	(0.026)
Diploma with GPA ≥ 8	0.049***	0.042***	0.037***	0.047***	0.040***	0.035***	0.043***	0.036***	0.029***
	(0.009)	(0.009)	(0.008)	(0.009)	(0.009)	(0.009)	(0.011)	(0.010)	(0.010)
Science or health field	0.066***	0.053**	0.044**	0.063***	0.052**	0.043*	0.044	0.035	0.030
	(0.020)	(0.021)	(0.020)	(0.024)	(0.024)	(0.023)	(0.029)	(0.029)	(0.028)
Grade retention	-0.007	0.010	0.024	-0.014	0.004	0.020	-0.004	0.014	0.030
	(0.020)	(0.021)	(0.020)	(0.024)	(0.024)	(0.024)	(0.030)	(0.030)	(0.029)
Changed school	0.037**	0.047***	0.055***	0.012	0.021	0.029	0.011	0.021	0.031
	(0.017)	(0.017)	(0.018)	(0.021)	(0.021)	(0.022)	(0.027)	(0.027)	(0.027)
N	4423	4423	4423	3092	3092	3092	3092	3092	3092
Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓
Polynomial of Cito score	Linear	Quadratic	Cubic	Linear	Quadratic	Cubic	Linear	Quadratic	Cubic

Note: Each estimate comes from a separate OLS regression of the outcome indicated in the row entry on a dummy variable for initial enrollment in an elite school. All columns include the controls listed below Table 3. Columns (1) to (3) are based on all students that enrolled in the pre-university track in the same years as the students who participated in the admission lotteries; columns (4) to (6) are restricted to students that were enrolled in elite schools that had lotteries and comprehensive schools that received lottery losers; columns (7) to (9) weigh students by the share of lottery participants that were placed in the school. Standard errors are clustered at the school of placement by cohort. ***p<0.01, **p<0.05, *p<0.10.