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DOI
10.1016/j.econedurev.2023.102363

Publication date
2023

Document Version
Final published version

Published in
Economics of Education Review

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Economics of Education Review 93 (2023) 102363

Contents lists available at ScienceDirect

Economics of Education Review

journal homepage: www.elsevier.com/locate/econedurev

Heterogeneous effects of comprehensive vs. single-track academic schools: Evidence from admission lotteries

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ARTICLE INFO

JEL classification:
I21
I24
C26

Keywords:
Elite schools
School value added
Treatment effects

ABSTRACT

We use admission lotteries to study how enrollment in a single-track academic school instead of a comprehensive school affects achievement of students in Amsterdam. The two types of schools score differently on measures of school quality and enrollment in a single-track school instead of a comprehensive school implies exposure to better and richer peers. Yet, school resources and the school curriculum are very similar. Different groups of students are differentially affected by this treatment. Girls from lower-income neighborhoods benefit whereas boys from these neighborhoods are harmed. For students from higher-income neighborhoods, it does not matter which type of school they attend.

1. Introduction

When students in the Netherlands transfer from primary school to secondary school (around the age of 12), they are assigned to one of three tracks (vocational, general or academic) based on the decision of their primary-school teacher.[2] The 20 to 25% of students who are placed in the academic track, can choose between two types of schools: comprehensive schools that offer the academic track together with one or two other tracks and single-track schools that exclusively offer the academic track. The two school types do not only differ in the tracks they offer. Single-track academic schools tend to attract better students and students from more affluent backgrounds (even within track). In addition, most of the single-track academic schools require their students to attend courses in Latin and Old Greek while such courses are optional in the academic tracks of comprehensive schools. There are also important similarities between the two school types. Both prepare their students for the same national exams at the end of secondary school and both give access to all universities and all fields of study in the Netherlands. Moreover, both school types are entirely publicly funded and have to comply with the same regulations set by the Dutch government. Furthermore, neither school type is allowed to select its students.

In the city of Amsterdam, the number of applicants to single-track academic schools exceeds the capacity of these schools. Some students are placed on the basis of sibling priority but for most applicants admission lotteries determine who gets in and who does not. These admission lotteries allow us to investigate the effects of enrollment in a single-track academic school instead of a comprehensive school for different groups of students. We consider differential effects by students' baseline ability, by the mean income in their neighborhood and by students' sex.

Knowledge about the – potentially heterogeneous – effects of different school types is important for parents, for schools and for policymakers. For parents such knowledge is important when they have to choose a school for their child. For schools it is important to know which types of students are best served by their teaching and which students may need extra facilities. For policymakers it is important when they decide about adjustment of school capacities or possible changes in the admission procedure (e.g. giving priority to students who are expected to benefit the most).

We use data from students who enrolled in the first year of a secondary school in Amsterdam in the years 2006 to 2010. During these years, the six single-track academic schools in Amsterdam conducted a

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1 A previous version of this paper circulated under the title " Using admission lotteries to estimate heterogeneous effects of elite schools" . We gratefully acknowledge valuable comments from two anonymous referees, William Foley, Monique de Haan, Edwin Leuven, Lisette Swart and seminar participants in Amsterdam, Maastricht, Oslo and The Hague. We thank Mark de Boer from Dienst Uitvoering Onderwijs (DUO) and the municipality of Amsterdam for supplying the data for this study.

2 This decision is informed by a nationwide testing system that follows students from age 6 onwards.

https://doi.org/10.1016/j.econedurev.2023.102363
Received 15 April 2022; Received in revised form 19 January 2023; Accepted 23 January 2023
Available online 6 February 2023

total of ten admission lotteries with 1118 participants. Because some of the students who lost an admission lottery are placed in a single-track academic school that was not oversubscribed in that year, we use an instrumental variable (IV) approach to address this noncompliance.

We show that winning an admission lottery leads to a change in school quality as measured by criteria reported by the Dutch Inspectorate of Education. It also results in a change in the composition of the peer group. The classmates of lottery winners score on average higher on baseline ability measures and come from more affluent social backgrounds than the classmates of lottery losers.

Considering the entire sample of lottery participants, we find that enrollment in a single-track academic school lowers the probability to obtain a diploma from the highest track on time or with up to three years of delay.[3] At the same time, we also find that enrollment in a single-track academic 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. Differentiation by ability shows that boys from both halves of the baseline ability distribution are harmed by enrollment in a single-track academic school, while the beneficial effects are concentrated amongst girls from the top half of the baseline ability distribution. Differentiation by neighborhood income shows that in particular boys from lower-income neighborhoods are harmed by enrollment in a single-track academic school, while the girls from these neighborhoods benefit. For students from higher-income neighborhoods the type of school does not seem to matter for their school outcomes.

We document substantial differences between the IV-estimates based on the sample of lottery participants and value-added estimates based on the entire sample of students in the academic track. These differences can be attributed to winning compliers having worse outcomes than always takers and students who are placed with priority, as well as to losing compliers having better outcomes than students in comprehensive schools who did not participate in the admission lotteries. This finding indicates that value-added estimates are of limited use to inform the school choices of the students who belong to the group of compliers in our setting.

In terms of education treatment, the single-track academic schools that we study here are comparable to the elite schools, selective schools and exam schools studied by Clark (2010), Jackson (2010), Pop-Eleches and Urquiola (2013), Dobbie and Fryer (2014), Abdulkadiroğlu et al. (2014), Lucas and Mbiti (2014), Angrist and Rokkanen (2015), Wu et al. (2019) and Barrow et al. (2020). Most importantly, admission to single-track academic schools and to elite, selective or exam schools implies exposure to high-achieving peers. But whereas admission to single-track academic schools in Amsterdam is based on lotteries, admission to elite, selective and exam schools is based on selection which the aforementioned studies exploit in regression discontinuity (RD) designs. Most of these studies find little evidence of positive effects on learning outcomes for students enrolled in these schools.[4] Because RD designs identify effects around the admission threshold, these results pertain to students who just qualify for admission. Angrist and Rokkanen (2015) develop a method to extrapolate the findings for marginal students to inframarginal students and conclude that these differ little. Our findings of negative effects for students at the lower end of the baseline ability distribution and positive effects for children at the top do not concur with the results from these previous studies.[5]

Since placement in a single-track academic school affects the peer composition, our study is also related to the peer-effects literature. This seems especially relevant for students with a relatively low baseline ability level. In a single-track academic school they belong to the weakest students while they are more likely to occupy an intermediate position in the academic track of a comprehensive school. While a linear-in-means peer-effects model predicts that all students benefit from being surrounded by better peers, more involved peer-effects models come to different results (cf. Booij et al., 2017; Duflo et al., 2011; Murphy & Weinhardt, 2020).[6] Some of our findings are consistent with the mechanisms proposed in these models.

Finally, our results are related to the literature that analyzes whether parents choose the school that fits the needs of their child best. Abdulkadiroğlu et al. (2020) find that parents choose schools with high-achieving peers which have larger returns on student outcomes. Preferences are, however, unrelated to school effectiveness and academic match quality after controlling for peer quality. Our results are in line with this. The findings of Cullen et al. (2006) and Beuermann and Jackson (2020) suggest that parents prefer schools that are not necessarily better in terms of traditional school outcomes but are beneficial for non-traditional outcomes such as crime, arrests and teenage motherhood. Given the low incidence of such outcomes in the student population attending the academic track in Dutch secondary schools, this does not seem an explanation for the choices of the parents of the students we study. We consider it more likely that some parents are misled by the favorable results of single-track academic schools on measures of school performance that ignore selection bias. Informing parents about the heterogeneous causal effects of single-track academic schools may then 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 single-track academic 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 of secondary education in the Netherlands and then the specific context of secondary school choice and admission lotteries in Amsterdam.[7]

[3] Three years is the maximum delay we can observe in our data. Longer delays are, however, very uncommon.

[4] Studies that find some positive effects are Jackson (2010), Pop-Eleches and Urquiola (2013) and Dobbie and Fryer (2014). Jackson (2010) reports positive effects on exam scores that are about twice as large for girls than for boys. Pop-Eleches and Urquiola (2013) find positive effects on graduation tests; they also document significant behavioral changes from teachers, children and parents. Dobbie and Fryer (2014) find positive impacts on short-term outcomes but no effects on long-term outcomes including college enrollment and graduation from college.

[5] Previous studies that have exploited lotteries to estimate school effects include Cullen et al. (2006), Hastings et al. (2006), Dobbie and Fryer (2011) and Abdulkadiroğlu et al. (2018). The schools included in these studies serve mainly students from poorer backgrounds and are therefore quite different from the single-track academic schools that we analyze.

[6] Duflo et al. (2011) argue that students benefit if their own level is not too far from the teacher's target level which depends on the composition of the students. Booij et al. (2017) find that not only the mean but also the standard deviation of peers' ability matters. Relatively low and median ability students have better outcomes when surrounded by students of their own ability level. Murphy and Weinhardt (2020) find that students' rank in class – independent of their absolute performance – affects their subsequent outcomes.

[7] We focus on single-track academic schools in Amsterdam because of the availability of data from the admission lotteries. The setting in Amsterdam is not very different from that in other large cities in the Netherlands. Secondary schools (single-track and comprehensive) in Amsterdam are in many dimensions comparable to schools in other cities (see Table A.1 in Appendix) and also elsewhere it is often the case that the single-track academic schools are oversubscribed (De Haan et al., 2022 document this for the city of Utrecht).

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 ability tracks. The lowest track (vocational) lasts four years and gives access to further vocational education programs.The intermediate track (general) takes five years and gives access to universities of applied sciences (professional colleges). The highest track (academic) takes six years and gives access to university education. Around 20 to 25% of the students enroll in the academic track, around 25% enroll in the general track, and the remaining students enroll in the vocational track.[8] 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.

Single-track academic 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. Single-track academic 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 as well as 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.[9]

Students in the Netherlands have free school choice, they are not restricted by catchment areas or school fees.[10] 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 mostly the same for all students in the academic track, independent of whether they are enrolled in a single-track academic 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.[11] In this system each student applied to one school in the first round. Schools that were not oversubscribed accepted all applicants in this round. Oversubscribed schools accepted all students with priority, and ran an admission lottery for the remaining places.[12] 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.[13]

Of the schools that offer the academic track, only single-track academic schools ran lotteries for the cohorts that we consider. For these cohorts, there were six single-track academic 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 single-track academic schools conducted lotteries in the years covered by our data.[14]

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 academic track and the numbers of students applying to single-track academic schools. In the years that we study, 4737 students were placed in the academic track and enrolled in a school in Amsterdam. We dropped 59 observations which could not be matched to education outcomes and 9 observations with missing information on key background variables. This results in a sample of 4669 students.

Six of the 31 schools that offer the academic track are single-track academic schools. Four of these six 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 academic track in these years. Of the 1450 students who applied to an oversubscribed single-track academic school, 332 were placed with priority and therefore exempted from the lottery.[15] This leaves us with a sample of 1118

[8] Within the vocational track there is a finer division into three subtracks that differ in the degree of practical orientation.

[9] In 2009, only 0.3% of Dutch secondary-school students attended a privately funded school (Dutch Inspectorate of Education, 2010).

[10] Public schools can request a voluntary parental contribution. The amounts suggested for these contributions are around 300 euros per year for the single-track academic schools in our study. This makes it unlikely that choices are restricted by financial motives.

[11] This was in 2015 replaced by the student-proposing Deferred Acceptance (DA) mechanism. In 2013 De Haan et al. (2023) collected data to compare allocations under the Boston and DA mechanisms. They find that 6.4% of the students chose strategically. This fraction is not different by student gender or background. The low share of strategic students is due to the high admission probabilities (over 75% in our sample). This means that the vast majority of the students would apply to the same school under Boston and under DA.

[12] 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 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.

[13] 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 & Sönmez, 2003). For students who lost the lottery in the first round, the municipality published information on which schools had vacant places. Students could apply to these schools in the second round. Schools that are oversubscribed in the second round conduct a lottery, there are no selective entry requirements. The number of students losing a lottery in the second round is quite small.

[14] In the years that we consider, other schools conducted admission lotteries for their general and vocational tracks. We do not analyze these lotteries here because there is no clear distinction between the lottery and non-lottery schools in these tracks. Because lotteries were conducted for each track separately, these other lotteries do not interfere with our analyses.

[15] Table A.2 in Appendix indicates that students with priority are somewhat less likely to have a disadvantaged background than students who participated in the admission lotteries.

Table 1
Number of observations.

Number of observations	Students	Schools	# Lotteries	Priority	Win	Lose
Students in academic track	4669	31				
Applying to single-track academic schools	3006	6				
Applying to single-track academic schools with lottery	2299	4				
Applying to single-track academic schools with lottery in lottery year	1450	4	10	332	836	282

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

lottery participants, of whom 836 won and 282 lost their lottery.[16] 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.

From the data supplied by DUO on school progress and exam performance, we constructed six student achievement measures. First, an indicator that equals one for students who graduated from the academic track without delay, otherwise zero. Next, three indicators that equal one for students who graduated from the academic track with at most one year delay, with at most two years delay, and with at most three years delay. Three years is the maximum delay we can observe in our data. Since longer delays are very exceptional, this is not an important restriction. Students who do not obtain the diploma from the academic track within nine years are unlikely to ever obtain it.We also created an indicator for the field of study that students specialize in during the last years in the academic track. The field of study strongly affects the options for tertiary education. As the science and health fields are considered to be more difficult and prestigious (Buser et al., 2014), and choosing these fields may affect whether a student graduates on time, we investigate whether placement in single-track academic schools affects the likelihood of choosing a science or health field. Finally, we create an indicator that equals one for students who graduated from the academic track without delay and with a GPA of at least 8 on a scale from 1 to 10 on the national exit exams. A GPA of at least 8 is the typical requirement for graduation with distinction (*cum laude*) and places a student in the top five percent of the GPA distribution at the academic 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. The other variable is an indicator that equals one if the student changed schools while in secondary education.

The DUO data contain information about students' sex, their migration background, their score on the exit test from primary school (Cito score) which we use as indicator of baseline ability,[17] whether they were retained or skipped a grade in primary school and whether they come from a one-parent family. There is no direct information in the data about students' social background. To proxy for this we use the mean income in the six-digits postal code area (street or part of a street) where the student lives.

Column (1) of Table 2 reports descriptive statistics of characteristics of students in the academic track who applied to a comprehensive school. Column (2) shows the difference in the mean values between academic-track students applying to comprehensive schools and academic-track students applying to single-track academic schools, together with their standard errors. This shows that students applying to single-track academic schools are from higher income 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 single-track academic 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.[18] Students who apply to single-track academic schools also have higher Cito scores. 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 single-track academic schools with a lottery (column (3)) and to students applying to a single-track academic school with a lottery in a year with a lottery (column (4)).

4. Empirical approach

To estimate theeffects of single-track academic schools on achievement we specify the following relationship between the academic achievement of student i who participated in admission lottery l (Y_{il}) and initial enrollment in a single-track academic school (ST_i):

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

where δ is the parameter of interest, 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. Because we consider multiple outcomes and subsamples, we report in addition to conventional (clustered) standard errors, also significance levels that correct for multiple hypotheses testing following the approaches of Anderson (2008) and Romano and Wolf (2005); see Section 6.4.

Because some of the students who lose an admission lottery find a place in a single-track academic school that did not conduct a lottery in that year, compliance with the results of the admission lottery is imperfect.[19] We therefore instrument ST_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:

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

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

[16] 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.

[17] 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 with a score of 545 or above should be assigned to the academic track. Students with lower scores can only be assigned to the academic track if their primary-school teacher makes a strong case for them and if supportive additional test results are provided.

[18] In the heterogeneity analysis, we do not use this indicator to proxy for social background because it equals one for only 5.5% of the students in single-track academic schools.

[19] In our data there is only one case of the other form of non-compliance; one lottery winner chose not to enroll in a single-track academic school.

Table 2
Differences in student characteristics between comprehensive and single-track academic schools.

Dependent variable	Mean (SD) for academic students applying to comprehensive schools (1)	Applying to single-track academic school (2)	Applying to single-track academic school with lottery (3)	Applying to single-track academic school in year with lottery (4)
Boy	0.485	0.026*	0.023	0.026
	(0.500)	(0.015)	(0.016)	(0.018)
Neighborhood income	2884.3	801.8***	766.7***	791.6***
	(1395.2)	(47.1)	(49.7)	(57.9)
Non-western migrant	0.388	−0.216***	−0.216***	−0.218***
	(0.488)	(0.014)	(0.014)	(0.016)
Western migrant	0.100	0.061***	0.052***	0.058***
	(0.301)	(0.010)	(0.011)	(0.012)
Weighted student funding	0.257	−0.194***	−0.199***	−0.210***
	(0.437)	(0.012)	(0.012)	(0.012)
Cito score	543.065	1.952***	1.794***	2.503***
	(7.275)	(0.220)	(0.232)	(0.241)
Grade retained in primary ed	0.019	−0.008**	−0.007*	−0.007
	(0.137)	(0.004)	(0.004)	(0.004)
Grade skipped in primary ed	0.018	0.011**	0.006	0.006
	(0.133)	(0.004)	(0.005)	(0.005)
One parent family	0.053	−0.018***	−0.019***	−0.021***
	(0.224)	(0.006)	(0.007)	(0.007)
Number of students	1663	4669	3962	3113

Note: Column (1) reports the means and standard deviations for students in the academic 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 a single-track academic school. In column (3), the indicator is 1 only for students applying to single-track academic schools that conduct lotteries and in column (4) the indicator is 1 only for students who apply to single-track academic 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.

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 a single-track academic 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 a single-track academic school increases the likelihood of initial enrollment in a single-track academic 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, 15 percentage points larger for students from the bottom half of the baseline ability distribution than for students from the top half, and 10 percentage points larger for students from students from lower income neighborhoods than for students from higher income neighborhoods.

Results from balancing tests are reported in Table 4. Columns (1) and (2) show the means and 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 ($F(9,1099)=0.75$; $p = 0.6598$).[20]

A concern with our instrumental variable approach is that it assumes that the result of the lottery only affects student outcomes through placement in a single-track academic school. This assumption is violated if students who lost the lottery but nevertheless enroll in a single-track academic school (always takers) 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 a single-track academic school" entails, this section presents estimates of the effect of the treatment on measures of school quality as reported by the Dutch Inspectorate of Education and on 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 a single-track academic 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 academic track within the school (which is the same as the school level for single-track academic schools).

The first three rows of the upper panel, and the first two rows of the lower panel of Table 5 report school quality indicators.[21] It turns out that enrollment in a single-track academic 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 assigned track. This result can either indicate that single-track academic schools are of lower quality for the lower grades, or could mean that single-track academic schools are more strict with respect to grade progression in these grades. The other

[20] Table A.6 in Appendix reports balancing results for the groups that are distinguished in the heterogeneity analysis.

[21] 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 academic track and on an average weighted by the number of students in each school track.

Table 3
First-stage results.

	N	First stage (1)	F-value	First stage (2)	F-value
Full sample	1108	0.491***	25.14	0.491***	25.52
		(0.098)		(0.097)	
Lowest 50% Cito score	581	0.567***	27.33	0.568***	28.56
		(0.108)		(0.106)	
Highest 50% Cito score	512	0.419***	18.43	0.420***	18.80
		(0.098)		(0.097)	
Boys	564	0.489***	23.00	0.488***	23.06
		(0.102)		(0.102)	
Girls	544	0.494***	24.02	0.490***	24.57
		(0.101)		(0.099)	
Non-western migrant	209	0.526***	20.13	0.510***	19.88
		(0.117)		(0.114)	
Native or western migrant	899	0.483***	23.09	0.482***	23.34
		(0.100)		(0.100)	
Lowest 50% income neighborhoods	544	0.551***	26.72	0.542***	26.23
		(0.107)		(0.106)	
Highest 50% income neighborhoods	539	0.440***	20.47	0.446***	21.15
		(0.097)		(0.097)	
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 a single-track academic 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 diploma from the academic track 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, neighborhood income, missing information on neighborhood income, 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	0.354
	(0.500)	(0.500)	(0.035)	
Neighborhood income	3558.9	3525.0	9.597	0.933
	(1610.7)	(1725.8)	(113.7)	
Non-western migrant	0.174	0.195	0.020	0.451
	(0.380)	(0.396)	(0.026)	
Western migrant	0.149	0.172	0.026	0.291
	(0.357)	(0.378)	(0.025)	
Weighted student funding	0.067	0.051	−0.021	0.211
	(0.251)	(0.221)	(0.017)	
Cito score	545.613	545.456	−0.210	0.603
	(6.778)	(6.087)	(0.403)	
Grade retained in primary ed	0.014	0.014	−0.002	0.765
	(0.118)	(0.119)	(0.008)	
Grade skipped in primary ed	0.021	0.025	0.002	0.846
	(0.145)	(0.157)	(0.010)	
One parent family	0.046	0.035	−0.011	0.445
	(0.210)	(0.183)	(0.014)	
Number of students	282	836	1118	

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.

two quality measures pertain to the higher grades, and indicate higher school quality at single-track academic schools. Enrollment in a single-track academic school implies enrollment in a school with a higher percentage of students without delay in the higher grades and a school with higher mean GPA on the final exams.

The other school measures give a more detailed view on other school characteristics of single-track academic schools. Enrollment in a single-track academic school means a school with a higher percentage of students in one-track classes in the first year. Single-track academic 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 the home to school distance between winning and losing compliers. Regarding the characteristics of the teachers in the different schools, we find that the mean age if not significantly different but that the share of female teachers is higher in schools attended by losing compliers than in schools attended by winning compliers. The explanation for this difference is probably that the share of female teachers is larger in the lower tracks that are offered in the comprehensive schools. We have no data to check which teachers in comprehensive schools are assigned to which tracks.[22]

[22] Some secondary schools in Amsterdam offer profiles focused on music, drama or sports. These profiles are, however not offered by the single-track

Table 5
Effects of single-track academic school enrollment on school characteristics.

Dependent variable	N (1)	Mean (SD) losing students (2)	Mean (SD) winning students (3)	IV estimates (4)
All school tracks				
Index grade progression lower grades	842	105.480 (9.333)	98.145 (2.418)	−9.637*** (3.102)
% no delay higher grades	842	64.682 (10.574)	72.503 (10.576)	6.270** (2.735)
GPA on final exams	842	6.356 (0.339)	6.666 (0.286)	0.389*** (0.060)
Number of students at entire school	842	930.539 (225.109)	875.024 (124.807)	−45.136 (49.066)
% students in single-track classes in first year	842	54.850 (40.058)	99.955 (1.166)	62.060*** (11.366)
% academic students with a science or health field	842	42.547 (11.777)	52.307 (4.598)	15.497*** (2.272)
Mean teacher age	1014	45.561 (1.868)	45.892 (1.932)	−0.400 (0.627)
% female teachers	1014	49.406 (3.623)	45.710 (3.381)	−6.820*** (1.706)
Pre-university track				
% no delay higher grades	842	62.952 (14.738)	72.003 (11.465)	7.376* (3.775)
GPA on final exams	842	6.347 (0.349)	6.659 (0.291)	0.373*** (0.063)
% academic students with a science or health field	842	47.624 (11.122)	53.572 (4.425)	11.876*** (2.579)
Distance to school in kilometers	1118	3.123 (2.006)	3.178 (2.179)	0.154 (0.301)

Note: The first column reports the numbers of observations, 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 from an IV regression, where winning the school admission lottery is the instrument for initial enrollment in a single-track academic school. 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.

With respect to the characteristics of students' first year peers, Table 6 shows that enrollment in a single-track academic school brings students a more advantaged peer group. Students in single-track academic schools have first-year peers from higher income neighborhoods and have fewer peers from one-parent families and fewer peers with a non-western migrant background. Firperson et al. (2022) show that school segregation of students by social background and ethnicity is highly correlated with segregation of teachers along the same dimensions. While we have no access to data for the schools attended by the lottery participants, we therefore consider it likely that the differences in the backgrounds of peers are accompanied by differences in backgrounds of teachers.

The peers in single-track academic schools achieve better academically than the peers in comprehensive schools. Their mean score on the exit test from primary school (Cito score) is higher, and its standard deviation smaller. Winning compliers who enroll in single-track academic 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 A.3 in Appendix shows that these differences not only hold at the school level but also at the track level.[23] Students enrolling in single-track academic schools have a higher percentage of peers in the academic track who attended the same primary school.[24]

To summarize, students who enroll in a single-track academic school after winning a school admission lottery attend schools with better peers in terms of prior academic achievement and peers (and teachers) from better social backgrounds 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. Single-track academic 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.

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 single-track academic schools by students' gender, baseline ability and neighborhood income. The third subsection compares the estimates based on admission lotteries with estimates from value-added models which condition on baseline ability and rich

academic schools. The comprehensive schools that offer these profiles typically do so to a few selected students in tracks below the academic track level. Extracurricular activities are, unlike elsewhere, not an important feature in Dutch education. The most prominent difference between the two school types is the destination of the one-week school-trip in the penultimate year. Where comprehensive schools may visit cities like Berlin, London or Paris, the single-track academic schools that require Latin and Greek will typically visit Rome or Athens.

[23] A noticeable difference between results at the school level and the school×track level is that winning students are in a smaller school-level cohort but in a larger school×track cohort. This does not reflect systematic differences in average class size between classes in single-track academic school and in the academic sections of comprehensive schools. In both school types, schools aim at class sizes between 26 to 29 students.

[24] Tables A.4 and A.5 in Appendix report IV estimates of the effects of enrollment in a single-track academic school on characteristics of the school and peers for different subgroups of students. These effects are by and large quite similar across groups. The most notable difference is that placement in a single-track school implies an increase in the home–school distance for boys and students from the bottom half of the baseline ability distribution, while there are no such effects for girls and students from the top half of the baseline ability distribution.

Table 6
Effects of single-track academic school enrollment on peer composition; all tracks.

Dependent variable	N	Mean (SD) losing students	Mean (SD) winning students	IV estimates
Mean Cito score	992	542.368	545.388	4.935***
		(3.987)	(2.791)	(0.539)
Rank Cito score	991	0.626	0.447	−0.317***
		(0.299)	(0.260)	(0.028)
Share of primary school peers	986	0.072	0.079	0.009
		(0.088)	(0.087)	(0.017)
Cohort size	992	164.448	139.367	−42.050***
		(57.866)	(16.543)	(13.775)
Share boys	992	0.525	0.523	−0.005
		(0.064)	(0.045)	(0.023)
Mean neighborhood income	992	3144.1	3682.6	982.5***
		(488.9)	(402.2)	(203.2)
Share non-western migrant	992	0.304	0.166	−0.248***
		(0.160)	(0.029)	(0.034)
Share western migrant	992	0.122	0.157	0.063***
		(0.035)	(0.029)	(0.021)
Share weighted student funding	992	0.154	0.041	−0.198***
		(0.114)	(0.019)	(0.032)
Share grade retained in primary ed	992	0.034	0.013	−0.041***
		(0.030)	(0.009)	(0.005)
Share grade skipped in primary ed	992	0.019	0.027	0.015**
		(0.018)	(0.014)	(0.007)
Share one parent family	992	0.058	0.028	−0.051***
		(0.036)	(0.013)	(0.009)

Note: See Table 5.

background information. The final subsection discusses results from various robustness analyses.

6.1. Full sample

Table 7 reports IV estimates of the effects of enrollment in single-track academic schools for the full sample of lottery participants. The first four rows show that enrollment in a single-track academic school reduces the probability to obtain the academic-track diploma. The probability to obtain the diploma on time decreases by around 12 percentage point, and the probabilities to obtain it with a delay of at most one, two and three years decrease by around 7.8, 6.5 and 6.2 percentage points, respectively. Because it is unlikely that someone obtains the academic-track diploma after the ninth year,[25] this means that enrollment in a single-track academic school instead of a comprehensive school reduces the probability to ever obtain the secondary-school diploma that gives access to university by around 6 percentage points. Consistent with these results, we see that enrollment in a single-track academic school leads to a higher probability of grade retention. At the same time, we find a marginally significant positive effect 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, we find no significant effects on specializing in the science and health fields or on changing school during secondary education.

When students do not obtain their academic-track diploma on time, this can either mean that they are grade retained or that they switched to a lower track. Fig. 1 shows IV estimates of the impact of single-track academic schools on students' year-to-year progression in secondary education. The solid line connects estimates for being in the academic track by year since the lottery. The dashed line connects estimates for being in the expected grade by year since the lottery. This reveals that the negative effects of single-track academic schools mainly arise through an negative effect of being in the expected grade (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 a single-track academic school are significantly less often in the academic track.

6.2. Heterogeneous effects

The combination of negative and positive effects in Table 7 suggests that some students are harmed by enrollment in a single-track academic school while others benefit from it. We examine heterogeneous effects along three dimensions: gender, baseline ability and neighborhood income. 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 sample median.[26] As measure of neighborhood income, we use the average income in the neighborhood (six-digits postal code area) of the student, and split the sample by the median neighborhood income for students in the academic track.[27] We repeat the previous analyses for three sample splits.

Columns (1) and (2) of Table 8 report results separately for boys and girls. These results show that the negative overall effects on obtaining the academic-track diploma on time or with at most one, two or three years delay are entirely due to boys and that the positive effect on obtaining the academic-track diploma with a GPA of at least 8.0 is completely due to girls. The differential effects for boys and girls is in line with the findings of Hastings et al. (2006) who study the impacts on academic outcomes of attending a first-choice school in a district in North Carolina. But while these authors can attribute the differential effects by gender partially to differences in effects on school quality, the results in Tables A.4 and A.5 reveal no substantial gender differences in the effects of enrollment in a single-track school on school and peer characteristics.

Column (2) also shows that enrollment in a single-track academic school reduces the probabilitythat girls specialize in the science or health fields by 11 percentage points. This is a large effect considering

[25] Notice that the control complier mean stabilizes after two years of delay at 0.835.

[26] When splitting the sample on baseline ability, we drop 15 students for which the score on the exit test from primary school is not available. 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 make no single mistake on the test. There is still variation in the results of students with the maximum score but this variation is not reported in the data.

[27] For the split on income, we drop 25 students for which the information on neighborhood income is not available.

Table 7
Effects of single-track academic schools on student achievement.

Outcome	N	CCM	(1)	(2)
Diploma academic track on time	1108	0.646	−0.132**	−0.116**
			(0.063)	(0.059)
Diploma academic track with at most one year delay	1108	0.820	−0.090*	−0.078*
			(0.048)	(0.046)
Diploma academic track with at most two years delay	1108	0.835	−0.074*	−0.065*
			(0.040)	(0.037)
Diploma academic track with at most three years delay	1108	0.835	−0.070*	−0.062*
			(0.039)	(0.036)
Diploma academic track with GPA ≥ 8	1069	0.032	0.046	0.055*
			(0.029)	(0.029)
Science or health fields	1093	0.513	−0.031	−0.037
			(0.060)	(0.057)
Grade retention	1108	0.294	0.126**	0.112**
			(0.052)	(0.050)
Changed school during secondary education	1118	0.247	−0.029	−0.037
			(0.058)	(0.061)
Controls				✓

Note: Each row reports two IV regressions with winning the school admission lottery as an instrument for initial enrollment in a single-track academic 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.

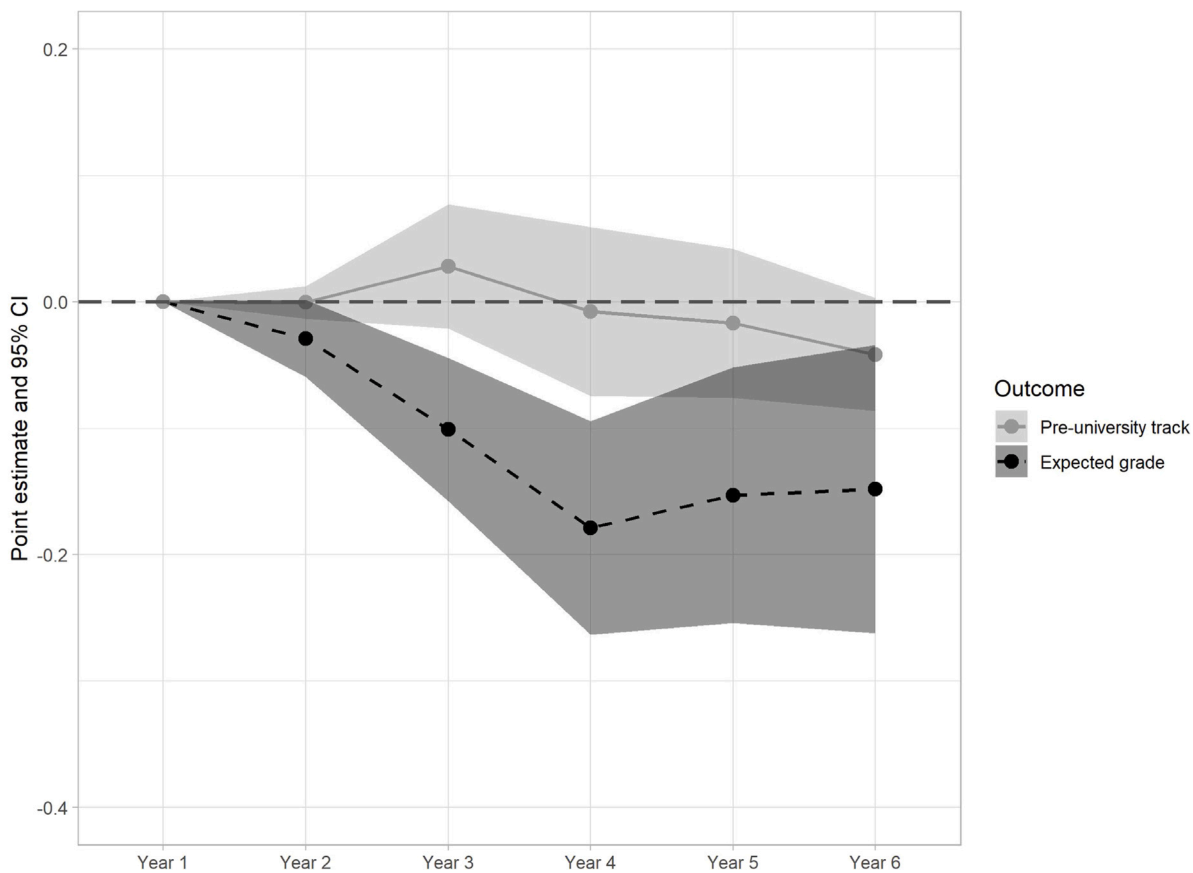

Fig. 1. Impact of single-track academic school attendance on secondary school progress.
Note: Each dot reports the result of an IV regression with winning the school admission lottery as an instrument for initial enrollment in a single-track academic school. The outcomes are whether students are in the academic 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 academic 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 54% percent of the girls choose one of these fields. This finding concurs with the results of Landaud et al. (2020) who using French data report that enrollment at a more selective high school causes girls, and not boys, to turn away from scientific fields.

Columns (3) and (4) report the results for the samples below and above the median of the baseline ability distribution. This reveals that the negative effect on obtaining the academic-track diploma on time is due to students from the bottom part of the ability distribution. The positive effect on obtaining the diploma with a GPA of at least 8.0 is, on the other hand, entirely due to students from the upper part. The negative impacts on obtaining the diploma with at most one, two or three years delay tend to be larger among the students in the

Table 8
Effects of single-track academic schools on student achievement for different groups.

Outcome	Boys (1)	Girls (2)	Lowest 50% Cito (3)	Highest 50% Cito (4)	Lowest 50% income (5)	Highest 50% income (6)
Diploma on time	−0.304***	0.041	−0.214***	0.064	−0.122*	−0.074
	(0.100)	(0.070)	(0.074)	(0.090)	(0.072)	(0.082)
Diploma at most 1 yr delay	−0.236***	0.076	−0.075	−0.039	−0.087*	−0.042
	(0.066)	(0.063)	(0.059)	(0.071)	(0.052)	(0.061)
Diploma at most 2 yrs delay	−0.172***	0.043	−0.067	−0.014	−0.087*	−0.021
	(0.053)	(0.054)	(0.050)	(0.055)	(0.049)	(0.046)
Diploma at most 3 yrs delay	−0.164***	0.039	−0.068	−0.006	−0.086*	−0.014
	(0.052)	(0.055)	(0.049)	(0.054)	(0.047)	(0.046)
Diploma with GPA ≥ 8	−0.013	0.111**	−0.004	0.147**	0.090*	0.022
	(0.046)	(0.043)	(0.021)	(0.064)	(0.051)	(0.054)
Science or health field	0.033	−0.111*	−0.075	0.065	0.005	−0.088
	(0.087)	(0.067)	(0.073)	(0.117)	(0.070)	(0.078)
Grade retention	0.237***	0.025	0.179**	−0.025	0.126*	0.050
	(0.092)	(0.065)	(0.072)	(0.074)	(0.067)	(0.068)
Changed school	0.039	−0.112	0.124**	−0.310***	−0.015	−0.083
	(0.062)	(0.085)	(0.050)	(0.113)	(0.098)	(0.077)
N	564	544	581	512	544	539

Note: Each estimate comes from a separate IV regression with winning the admission lottery as instrument for initial enrollment in a single-track academic school. Relevant subsample is indicated in the column entries, numbers of observations are reported in bottom row. 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.

bottom part but these estimates lack precision. Single-track academic 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 (5) and (6) report the results for the samples below and above the median for neighborhood income. This shows that both the negative effects of single track academic schools on obtaining the diploma as well as the positive effects on obtaining the diploma with a high GPA are concentrated among students from the lower income neighborhoods.[28]

The findings in Table 8 warrant an analysis by combined baseline ability, neighborhood income and gender groups. We therefore split the sample into two times four subsamples: boys below the median, girls below the median, boys above the median and girls above the median for both baseline ability and neighborhood income. The sizes of these subsamples are between 250 and 300 observations per subsample, which reduces precision. Nevertheless, the results in Table 9 reveal some clear patterns. First, in columns (1) to (4) negative effects on obtaining the academic-track diploma with at most one, two and three years delay are found for boys from both parts of the ability distribution. Second, a positive effect on obtaining the academic-track diploma on time with a GPA of at least 8.0 is only found for girls from the upper part of the ability distribution. Finally, a negative effect for girls to choose the science or health fields is only found for girls from the lower part of the ability distribution. This also means that the positive effect for girls from the upper part to graduate with a high GPA is not due to them specializing in less demanding fields.

The results in columns (5) and (6) reveal sizable differences between boys and girls from the lower-income neighborhoods. For boys from lower-income neighborhoods, single-track academic schools have negative effects on obtaining the academic track diploma on time, with at most one, two and three years delay and increase the probability of grade retention. In contrast, for girls from lower-income neighborhoods, single-track academic schools have positive effects on obtaining the academic-track diploma with at most one, two and three years delay and on obtaining the academic-track diploma on time with a GPA of at least 8.0. Finally, columns (7) and (8) show no significant effects of the type of school on school outcomes for students from higher-income neighborhoods. The only exception is that girls from these neighborhoods are less likely to choose the science and health fields when enrolled in a single-track academic school.

Due to the small sizes of the subsamples, the estimates in Table 9 are fairly imprecise. As a result quite substantial positive effects on obtaining a diploma for girls with high baseline ability and sizable negative effects on obtaining a diploma for boys from high income families fall within the 95% confidence intervals.

6.3. Comparison with value-added estimates

Table 10 reports results from OLS regressions of school outcomes on a dummy variable for enrollment in a single-track academic 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 (or teachers) is random conditional on control variables.

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.[29] 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 indicate that enrollment in a single-track academic school increases the probability to obtain the academic-track diploma and has a negative 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 academic-track 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 single-track academic schools that conducted admission lotteries and to comprehensive schools that placed students who participated in the admission lotteries for single-track academic schools. Columns (5) and (6) use the same sample as columns (3) and (4) but weigh students' schools

[28] We have also inquired whether single-track academic schools have differential effects by ethnicity. Table A.11 in Appendix shows that effects are quite similar for students with a non-western migrant background and for other students.

[29] 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.

Table 9
Effects of single-track academic schools on student achievement for different groups.

Outcome	Lowest 50% Cito		Highest 50% Cito		Lowest 50% income		Highest 50% income	
	Boys (1)	Girls (2)	Boys (3)	Girls (4)	Boys (5)	Girls (6)	Boys (7)	Girls (8)
Diploma on time	−0.354***	−0.083	−0.051	0.168	−0.394**	0.101	−0.173	0.012
	(0.122)	(0.096)	(0.164)	(0.115)	(0.161)	(0.067)	(0.113)	(0.144)
Diploma at most 1 yr delay	−0.179***	0.029	−0.252**	0.109	−0.385***	0.149**	−0.103	0.017
	(0.069)	(0.093)	(0.100)	(0.094)	(0.112)	(0.067)	(0.089)	(0.100)
Diploma at most 2 yrs delay	−0.144**	−0.007	−0.180**	0.098	−0.369***	0.136**	−0.003	−0.049
	(0.062)	(0.088)	(0.087)	(0.069)	(0.111)	(0.062)	(0.073)	(0.080)
Diploma at most 3 yrs delay	−0.139**	−0.004	−0.171**	0.098	−0.353***	0.114*	−0.003	−0.031
	(0.061)	(0.089)	(0.084)	(0.069)	(0.106)	(0.063)	(0.073)	(0.080)
Diploma with GPA ≥ 8	−0.033	0.039	0.138	0.216***	−0.001	0.144***	−0.008	0.033
	(0.042)	(0.033)	(0.111)	(0.082)	(0.086)	(0.042)	(0.068)	(0.080)
Science or health field	0.000	−0.182**	0.169	−0.030	0.071	−0.091	0.003	−0.199*
	(0.104)	(0.090)	(0.207)	(0.126)	(0.117)	(0.085)	(0.121)	(0.117)
Grade retention	0.256**	0.138	0.022	−0.092	0.335**	−0.035	0.063	0.065
	(0.116)	(0.104)	(0.156)	(0.088)	(0.146)	(0.079)	(0.113)	(0.121)
Changed school	0.181**	0.079	−0.282	−0.324***	0.104	−0.122	−0.028	−0.132
	(0.076)	(0.106)	(0.191)	(0.112)	(0.142)	(0.107)	(0.078)	(0.134)
N	300	281	254	258	274	270	275	264

Note: Each estimate comes from a separate IV regression with winning the admission lottery as instrument for initial enrollment in a single-track academic school. Relevant subsample is indicated in the column entries, numbers of observations are reported in bottom row. 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 10
Value added estimates of single-track academic schools relative to comprehensive schools.

Outcome	Single-track academic schools vs. all comprehensive schools with pre-university students		Single-track academic schools with lotteries vs. comprehensive schools with lottery losing students		Single-track academic 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	0.132***	0.079***	0.131***	0.074***	0.106***	0.063**
	(0.023)	(0.021)	(0.026)	(0.026)	(0.030)	(0.031)
Diploma at most 1 yr delay	0.175***	0.124***	0.175***	0.118***	0.148***	0.108***
	(0.019)	(0.017)	(0.022)	(0.021)	(0.027)	(0.027)
Diploma at most 2 yrs delay	0.186***	0.140***	0.185***	0.134***	0.153***	0.119***
	(0.018)	(0.016)	(0.021)	(0.020)	(0.025)	(0.027)
Diploma at most 3 yrs delay	0.187***	0.144***	0.187***	0.139***	0.156***	0.126***
	(0.018)	(0.017)	(0.022)	(0.021)	(0.026)	(0.029)
Diploma with GPA ≥ 8	0.061***	0.053***	0.062***	0.052***	0.057***	0.048***
	(0.010)	(0.010)	(0.010)	(0.011)	(0.011)	(0.013)
Science or health field	0.074***	0.067***	0.068***	0.064***	0.047*	0.047
	(0.020)	(0.021)	(0.022)	(0.024)	(0.026)	(0.029)
Grade retention	−0.053**	−0.001	−0.066***	−0.007	−0.047	0.001
	(0.021)	(0.021)	(0.024)	(0.026)	(0.030)	(0.031)
Changed school	0.013	0.036**	−0.007	0.013	−0.018	0.012
	(0.016)	(0.017)	(0.019)	(0.022)	(0.026)	(0.027)
N	4430	4430	3099	3099	3099	3099
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 a single-track academic 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 academic 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 single-track academic 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.

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.

To understand the differences between the value-added estimates and the lottery-based estimates, Table A.12 in the Appendix reports mean outcomes (not effects) for different groups of treated and untreated students. This shows that students in single-track academic schools who are not included in the IV-estimates (always takers and students placed with priority) have better outcomes than students in single-track academic schools who are included in these estimates (winning compliers).[30] 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).

One interpretation of a comparison of value-added estimates and lottery-based estimates is that in case of similarities the lottery-based estimates validate the value-added measures (e.g. Deming, 2014) and that in case of differences the lottery-based estimates invalidate the

[30] The outcomes for always takers are observed as the outcomes of students who lost the lottery but yet enrolled in a single-track academic school. Since these students generally enroll in another single-track academic 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.

value-added measures (e.g. Angrist et al., 2020). Given the substantial effect heterogeneity that we find in our lottery-based design, another interpretation of these differences is that they reflect effect heterogeneity between the compliers in our setting and other students. We can, however, conclude that our value-added estimates are not informative about the effects of winning or losing the admission lottery for the compliers in out setting. Hence the value-added estimates are not a good guide for the school choices of these compliers.

6.4. Robustness

In Tables 7 and 8 we report results from regressions where we include per outcome as many observations as possible. As a result the sample sizes differ somewhat between outcomes. Tables A.7 and A.8 in Appendix report results where we use the same (sub)samples across different outcomes. This adjustment only has a minor influence on the estimates.

Because we consider eight outcomes and analyze heterogeneous effects for different subgroups, we also report significance levels that correct for multiple hypotheses testing. We report sharpened q-values which account for the false discovery rate (FDR) following the approach proposed by Anderson (2008) as well as p-values that control for the familywise error rate (FWER) following the approach of Romano and Wolf (2005) Clarke et al. (see also 2020). Tables A.9 and A.10 report the conventional p-values for the estimates in Tables 7 to 9 together with the FDR q-values and the FWER p-values. Some of the FWER p-values and all FDR q-values corresponding to the results in Table 7 are all above 0.10, meaning that the significant findings in this table do not survive both corrections for multiple hypotheses testing. This is, however, not the case for the key results for subgroups. Boys, in particular from below median income neighborhoods, are less likely to obtain a diploma from the academic track while girls from these neighborhoods are more likely to obtain a diploma with high GPA.

Four of the six single-track academic 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 possible to infer results for individual schools.

We chose the threshold of 8.0 for high GPA because this is often required for graduation with distinction ("*cum laude*"). Appendix Tables A.13 and A.14 report results for other thresholds. Results are similar when a threshold of 7.5 or 8.5 is chosen. Coefficients are similar, but less precise, for a threshold at 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 A.15 show that this is not the case. While the requirement to do exams in Latin and Greek does not drive the difference in pass rates and GPA, exposure to these subjects can contribute to the differences in terms of disciplining students or triggering a different type of curiosity or engagement.

The value-added results reported in Table 10 control linearly for the Cito score. Table A.16 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 single-track academic schools in Amsterdam to show that effects of enrollment in such a school instead of a comprehensive school are heterogeneous by gender, baseline ability and neighborhood income. When differentiating by ability we find that boys from both halves of the baseline ability distribution are harmed by enrollment in a single-track academic school, while only girls from the top half of that distribution benefit. When differentiating by social background we find that boys from lower-income neighborhoods are harmed by enrollment in a single-track academic school, while girls from these neighborhoods benefit. For students from higher-income neighborhoods (boys and girls) it does not matter what type of school they attend.

Most of the patterns by ability can be rationalized by combining different findings from the peer effects literature. The negative effect for low-ability boys is consistent with the rank effect mechanism proposed by Murphy and Weinhardt (2020) and a larger distance to the teachers' target levels proposed by Duflo et al. (2011). The positive effect for high-ability girls is consistent with the standard linear-in-means model as well as with the models proposed by Duflo et al. (2011) and by Booij et al. (2017) (students perform better in more homogeneous classes). The zero effect for low-ability girls suggests that negative effects of rank and distance to the teachers' target levels are cancelled out by positive effects from better peers and more homogeneous classes. The negative effect for high-ability boys suggests that for this group, the negative effect of lower rank dominates other mechanisms. The results for boys from lower-income neighborhoods suggest that for these boys the conflict between school effort and notions of masculinity (cf. Legewie & DiPrete, 2012) is more salient in single-track academic schools than in comprehensive schools. The absence of teachers with a similar background may contribute to this conflict. The results for students from higher-income neighborhoods are consistent with affluent families being able to compensate for variations in the school environment (e.g. Fredriksson et al., 2016).

We have also compared the lottery-based results 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 quite different from the lottery-based estimates. This indicates that the value-added results would be a poor guide for the school choices of the compliers in our setting. 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 parents whose child would be better off in a comprehensive school chose to enroll their child in a single-track academic 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 single-track academic 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 single-track academic schools for students for whom these schools are beneficial and who may otherwise lose a lottery.

CRediT authorship contribution statement

Hessel Oosterbeek: Conceptualization, Methodology, Writing, Supervision. **Nienke Ruijs:** Conceptualization, Methodology, Software, Validation, Formal analysis, Writing. **Inge de Wolf:** Conceptualization, Methodology, Writing – review & editing, Supervision.

Data availability

The authors do not have permission to share data.

Appendix. Additional tables

This Appendix includes additional tables.

Table A.1 reports differences in school characteristics between schools in Amsterdam and schools in the next three, and the next 27, largest cities in the Netherlands. This is done separately for single-track (academic) schools and comprehensive schools. It shows that most of the differences are small and not significantly different from zero. The main difference is that single-track schools in Amsterdam are larger than single-track schools elsewhere, whereas comprehensive schools in Amsterdam tend to be smaller than elsewhere. Also, comprehensive schools in Amsterdam have a higher share of female teachers than comprehensive schools elsewhere but the difference is small.

Table A.2 reports descriptive statistics of student characteristics separately for student participating in admission lotteries for single-track academic 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 single-track academic schools.

Table A.3 reports IV estimates of the effects of enrollment in single-track academic schools on peer characteristics at the academic track level. Tables A.4 and A.5 report IV estimates of the effects of enrollment in single-track schools on school characteristics and peer characteristics for subgroups of students.

Table A.6 reports balancing results for the groups we distinguish in the heterogeneity analysis.

Tables A.7 and A.8 where the (sub)samples are kept constant across the eight different outcomes that we consider. Results are very similar to those reported in the main text.

Table A.1
Differences between schools in Amsterdam and schools in other (large) Dutch cities.

Dependent variable	Single track schools		Comprehensive schools	
	G4 (1)	G27 (2)	G4 (3)	G27 (4)
Index grade progression lower grades	0.283	−2.250	−1.777	−1.628
	(1.461)	(1.861)	(1.760)	(1.551)
Number of students at entire school	191.865**	96.894	−35.390	−295.408***
	(89.264)	(71.542)	(101.794)	(92.183)
Mean teacher age	−0.081	−0.466	0.464	−0.298
	(0.586)	(0.488)	(0.676)	(0.617)
% female teachers	1.177	2.569	3.633**	4.262***
	(3.212)	(2.552)	(1.585)	(1.224)
% no delay higher grades	−6.338	−3.126	0.756	−3.897
	(5.896)	(5.509)	(3.057)	(2.582)
GPA on final exams	0.016	0.047	0.047	−0.111*
	(0.168)	(0.152)	(0.077)	(0.059)
% pre-uni students with a science or health field	−0.947	−1.639	0.110	−1.355
	(3.242)	(2.848)	(2.313)	(1.926)

Note: The table reports differences in school characteristics between schools in Amsterdam and schools in the other three large cities in the Netherlands (Rotterdam, The Hague and Utrecht) in columns (1) and (3) and between schools in Amsterdam and the next 27 largest cities in the Netherlands in columns (2) and (4). Columns (1) and (2) report differences for single-track (academic) schools, columns (3) and (4) report differences for comprehensive schools. Standard errors in parentheses. ***p<0.01, **p<0.05, *p<0.10.

Table A.2
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	0.005	0.879
	(0.501)	(0.500)	(0.032)	
Neighborhood income	4154.9	3533.6	−547.2	0.000
	(1959.4)	(1696.8)	(118.6)	
Non-western migrant	0.105	0.190	0.084	0.000
	(0.308)	(0.392)	(0.021)	
Western migrant	0.130	0.166	0.043	0.054
	(0.336)	(0.373)	(0.022)	
Weighted student funding	0.018	0.055	0.032	0.002
	(0.133)	(0.229)	(0.010)	
Cito score	545.810	545.496	0.249	0.447
	(5.789)	(6.266)	(0.328)	
Grade retained in primary ed	0.006	0.014	0.009	0.117
	(0.077)	(0.119)	(0.006)	
Grade skipped in primary ed	0.024	0.024	−0.002	0.802
	(0.154)	(0.154)	(0.010)	
One parent family	0.015	0.038	0.022	0.015
	(0.122)	(0.190)	(0.009)	
Number of students	332	1118		

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 A.3
Effects of single-track academic school enrollment on peer composition; academic track.

Dependent variable	N	Mean (SD) losing students	Mean (SD) winning students	IV estimates
Mean Cito score	992	544.539	545.401	1.093**
		(3.110)	(2.791)	(0.488)
Rank Cito score	991	0.509	0.446	−0.111***
		(0.278)	(0.260)	(0.024)
Share of primary school peers	963	0.093	0.198	0.185***
		(0.147)	(0.176)	(0.032)
Cohort size	992	77.422	138.734	110.090***
		(40.638)	(15.757)	(7.794)
Share of Boys	992	0.518	0.524	0.009
		(0.079)	(0.045)	(0.025)
Mean neighborhood income	992	3239.6	3682.6	815.0***
		(510.0)	(404.2)	(221.4)
Share of non-western migrant	992	0.252	0.166	−0.155***
		(0.128)	(0.029)	(0.033)
Share of western migrant	992	0.124	0.158	0.061**
		(0.049)	(0.029)	(0.025)
Share of weighted student funding	992	0.136	0.042	−0.167***
		(0.122)	(0.019)	(0.037)
Share grade retained in primary ed	992	0.006	0.012	0.008**
		(0.011)	(0.007)	(0.004)
Share grade skipped in primary ed	992	0.030	0.027	−0.005
		(0.022)	(0.014)	(0.009)
Share one parent family	992	0.039	0.029	−0.019**
		(0.026)	(0.013)	(0.008)

Note: See Table 5.

Table A.4
Effects of single-track academic school enrollment on school characteristics for different groups.

Dependent variable	Full sample	Boys	Girls	Cito		Income	
				Lowest 50%	Highest 50%	Lowest 50%	Highest 50%
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
All school tracks							
Index grade progression lower grades	−9.637***	−9.575***	−9.716***	−9.893***	−9.425***	−8.889**	−10.384***
	(3.102)	(3.191)	(3.202)	(3.139)	(3.238)	(3.715)	(2.801)
% no delay higher grades	6.270**	6.630**	6.319*	4.100*	9.037**	4.647*	7.764**
	(2.735)	(2.606)	(3.390)	(2.280)	(3.878)	(2.705)	(3.023)
Average grade on final exams	0.389***	0.373***	0.413***	0.368***	0.414***	0.357***	0.412***
	(0.060)	(0.069)	(0.062)	(0.053)	(0.084)	(0.054)	(0.071)
Number of students at entire school	−45.136	−83.435	2.655	−52.156	−35.912	−40.306	−47.089
	(49.066)	(59.117)	(42.507)	(63.557)	(38.632)	(39.821)	(64.627)
% students in one-track classes in first year	62.060***	63.113***	62.556***	65.679***	57.361***	55.781***	66.933***
	(11.366)	(10.501)	(13.439)	(9.777)	(13.207)	(11.035)	(11.426)
% academic students in higher grades	11.843***	12.265***	11.522***	12.759***	10.893***	12.121***	11.998***
	(4.026)	(4.160)	(4.094)	(4.231)	(3.959)	(4.338)	(4.042)
% academic students with a science or health field	15.497***	17.260***	14.080***	15.929***	14.822***	15.536***	15.568***
	(2.272)	(2.277)	(2.325)	(1.977)	(2.981)	(2.106)	(2.599)
Mean teacher age	−0.400	−0.591	−0.259	−0.265	−0.624	−0.284	−0.536
	(0.627)	(0.739)	(0.605)	(0.592)	(0.774)	(0.721)	(0.599)
% female teachers	−6.820***	−7.210***	−6.577***	−5.358***	−8.721***	−6.503***	−7.228***
	(1.706)	(1.944)	(1.608)	(1.494)	(2.460)	(1.564)	(2.109)
Pre-university track							
% no delay higher grades	7.376*	6.896**	8.190*	5.973*	9.361*	4.906	9.715**
	(3.775)	(3.159)	(4.830)	(3.325)	(4.784)	(4.029)	(3.914)
Average grade on final exams	0.373***	0.360***	0.392***	0.353***	0.396***	0.345***	0.394***
	(0.063)	(0.074)	(0.062)	(0.054)	(0.088)	(0.060)	(0.072)
% pre-uni students in higher grades	37.719***	37.153***	38.609***	36.384***	39.519***	39.311***	36.826***
	(5.270)	(5.299)	(5.635)	(5.420)	(5.602)	(4.936)	(6.026)
% pre-uni students with a science or health field	11.876***	13.998***	9.832***	12.359***	11.086***	11.501***	12.215***
	(2.579)	(2.746)	(2.481)	(2.231)	(3.307)	(2.582)	(2.801)
Distance to school in kilometers	0.154	0.896**	−0.520	0.799***	−0.613	0.244	0.254
	(0.301)	(0.416)	(0.389)	(0.309)	(0.535)	(0.386)	(0.413)

Table A.5
Effects of single-track academic school enrollment on peer characteristics for different groups.

Dependent variable	Full sample	Boys	Girls	Cito		Income	
				Lowest 50%	Highest 50%	Lowest 50%	Highest 50%
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Mean Cito score	4.935***	5.067***	4.829***	4.797***	5.130***	5.033***	4.891***
	(0.539)	(0.562)	(0.537)	(0.618)	(0.509)	(0.564)	(0.541)
Rank Cito score	−0.317***	−0.338***	−0.292***	−0.369***	−0.224***	−0.326***	−0.306***
	(0.028)	(0.030)	(0.040)	(0.046)	(0.025)	(0.031)	(0.039)
Share of primary school peers	0.009	0.022	−0.002	0.009	0.011	−0.009	0.026
	(0.017)	(0.019)	(0.018)	(0.020)	(0.020)	(0.016)	(0.021)
Cohort size	−42.050***	−42.497***	−40.324***	−42.521***	−41.295***	−45.020***	−40.710***
	(13.775)	(14.869)	(14.175)	(14.013)	(14.419)	(13.592)	(15.220)
Share of boys	−0.005	0.002	−0.010	−0.016	0.011	−0.008	0.002
	(0.023)	(0.030)	(0.020)	(0.021)	(0.027)	(0.024)	(0.023)
Mean neighborhood income	982.5***	1002.2***	961.7***	925.7***	1058.9***	984.8***	965.1***
	(203.2)	(214.4)	(201.3)	(189.8)	(235.8)	(159.6)	(259.6)
Share of non-western migrant	−0.248***	−0.234***	−0.259***	−0.262***	−0.226***	−0.261***	−0.235***
	(0.034)	(0.036)	(0.035)	(0.036)	(0.033)	(0.030)	(0.040)
Share western migrant	0.063***	0.063***	0.062***	0.058***	0.069***	0.068***	0.055***
	(0.021)	(0.021)	(0.021)	(0.019)	(0.023)	(0.021)	(0.021)
Share weighted student funding	−0.198***	−0.200***	−0.198***	−0.210***	−0.181***	−0.207***	−0.189***
	(0.032)	(0.033)	(0.034)	(0.034)	(0.032)	(0.026)	(0.039)
Share grade retained in primary ed	−0.041***	−0.041***	−0.041***	−0.043***	−0.038***	−0.042***	−0.041***
	(0.005)	(0.006)	(0.005)	(0.006)	(0.005)	(0.005)	(0.006)
Share grade skipped in primary ed	0.015**	0.011	0.018***	0.015**	0.014**	0.018***	0.011
	(0.007)	(0.008)	(0.005)	(0.006)	(0.007)	(0.005)	(0.008)
Share one parent family	−0.051***	−0.049***	−0.052***	−0.050***	−0.054***	−0.052***	−0.051***
	(0.009)	(0.008)	(0.010)	(0.009)	(0.010)	(0.008)	(0.011)

Table A.6
Balancing results for different groups.

	Full sample	Boys	Girls	Cito		Income	
				Lowest 50%	Highest 50%	Lowest 50%	Highest 50%
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Boy	0.032			0.053	0.005	0.045	0.018
	(0.035)			(0.049)	(0.050)	(0.051)	(0.049)
Neighborhood	9.597	−165.664	225.275	−63.750	93.990	−24.710	98.771
income	(113.739)	(161.401)	(167.537)	(159.465)	(164.402)	(47.405)	(156.961)
Non-western	0.020	−0.004	0.037	0.048	−0.013	0.028	0.005
migrant	(0.026)	(0.037)	(0.038)	(0.038)	(0.036)	(0.045)	(0.027)
Western	0.026	0.051	0.003	0.059*	−0.007	0.026	0.026
migrant	(0.025)	(0.035)	(0.037)	(0.034)	(0.037)	(0.039)	(0.033)
Weighted student funding	−0.021	−0.038	−0.008	−0.032	−0.009	−0.037	−0.010
	(0.017)	(0.025)	(0.023)	(0.025)	(0.022)	(0.032)	(0.011)
Cito score	−0.210	−0.809	0.340	0.026	0.067	−0.035	−0.337
	(0.403)	(0.563)	(0.580)	(0.616)	(0.120)	(0.610)	(0.546)
Grade retained	−0.002	−0.022	0.016***	−0.010	0.006	−0.007	0.002
in primary ed	(0.008)	(0.015)	(0.006)	(0.012)	(0.010)	(0.010)	(0.012)
Grade skipped	0.002	0.024**	−0.021	−0.008	0.010	−0.017	0.018*
in primary ed	(0.010)	(0.011)	(0.017)	(0.017)	(0.011)	(0.018)	(0.011)
One parent family	−0.011	−0.022	0.002	−0.025	0.005	−0.032	0.008
	(0.014)	(0.022)	(0.018)	(0.019)	(0.021)	(0.025)	(0.013)
Number of students	1118	569	549	586	532	548	544

Note: Each cell reports separate regression coefficients 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. Samples used for estimation are indicated by the column entries. All regressions include lottery fixed effects. Robust standard errors are reported in parentheses.

Table A.7
Effects of single-track academic schools on student achievement – Constant sample size.

Outcome	N	CCM	(1)	(2)
Diploma academic track on time	1067	0.671	−0.124**	−0.115**
			(0.060)	(0.057)
Diploma academic track with at most one year delay	1067	0.853	−0.077*	−0.070
			(0.043)	(0.043)
Diploma academic track with at most two years delay	1067	0.868	−0.068**	−0.064**
			(0.034)	(0.032)
Diploma academic track with at most three years delay	1067	0.868	−0.064**	−0.060*
			(0.033)	(0.031)
Diploma academic track with GPA ≥ 8	1067	0.032	0.047	0.055*
			(0.029)	(0.029)
Science or health fields	1067	0.513	−0.034	−0.043
			(0.061)	(0.058)
Grade retention	1067	0.282	0.115**	0.106**
			(0.052)	(0.050)
Changed school during secondary education	1067	0.237	−0.053	−0.057
			(0.060)	(0.064)
Controls				

Note: Each row reports two IV regressions with winning the school admission lottery as an instrument for initial enrollment in a single-track academic 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.

Table A.8
Effects of single-track academic schools on student achievement for different groups — Constant sample size.

Outcome	Boys (1)	Girls (2)	Lowest 50% Cito (3)	Highest 50% Cito (4)	Lowest 50% income (5)	Highest 50% income (6)
Diploma on time	−0.267***	0.010	−0.217***	0.062	−0.123*	−0.082
	(0.095)	(0.066)	(0.076)	(0.084)	(0.073)	(0.077)
Diploma at most 1 yr delay	−0.182***	0.042	−0.066	−0.042	−0.084*	−0.043
	(0.054)	(0.054)	(0.055)	(0.063)	(0.050)	(0.062)
Diploma at most 2 yrs delay	−0.122***	−0.000	−0.064	−0.024	−0.089*	−0.033
	(0.044)	(0.046)	(0.045)	(0.047)	(0.046)	(0.045)
Diploma at most 3 yrs delay	−0.114***	−0.005	−0.064	−0.015	−0.087**	−0.025
	(0.043)	(0.047)	(0.044)	(0.046)	(0.044)	(0.045)
Diploma with GPA ≥ 8	−0.013	0.111**	−0.003	0.147**	0.090*	0.022
	(0.046)	(0.043)	(0.021)	(0.064)	(0.051)	(0.054)
Science or health field	0.027	−0.113	−0.080	0.059	0.014	−0.118
	(0.088)	(0.070)	(0.076)	(0.117)	(0.072)	(0.080)
Grade retention	0.233**	0.013	0.194***	−0.053	0.132*	0.039
	(0.092)	(0.066)	(0.072)	(0.079)	(0.068)	(0.069)
Changed school	0.001	−0.118	0.104**	−0.322***	−0.039	−0.090
	(0.065)	(0.090)	(0.050)	(0.119)	(0.100)	(0.077)
N	544	523	552	500	521	521

Note: Each estimate comes from a separate IV regression with winning the admission lottery as instrument for initial enrollment in a single-track academic school. Relevant subsample is indicated in the column entries, numbers of observations are reported in bottom row. 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.

Tables A.9 and A.10 report the conventional p-values for the estimates in Tables 7 to 9 together with the FDR q-values (cf. Anderson, 2008) and the FWER p-values (cf. Clarke et al., 2020; Romano & Wolf, 2005).

Table A.11 reports IV estimates of the effects of enrollment in single-track academic 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 A.12 reports mean outcomes (not effects) for different groups of treated and untreated students. Column (1) pertains to lottery participants who enrolled in a single-track academic school because they won a lottery (treated compliers). Column (2) pertains to lottery participants who enrolled in a single-track academic school irrespective of the lottery result (always takers). Column (3) reports mean outcomes for students who enrolled in a single-track academic 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 a single-track academic school and enrolled in a comprehensive school.

Tables A.13 and A.14 show results for the effect of enrollment in a single-track academic school on obtaining the academic-track diploma on time with a GPA above certain thresholds.

Table A.15 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 A.16 presents results from the value added approach for different polynomials of baseline ability (Cito score).

Table A.9
p-values, FDR *q*-values and FWER *p*-values.

Outcome	Full sample	Boys	Girls	Cito		Income	
				Lowest 50%	Highest 50%	Lowest 50%	Highest 50%
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Diploma on time	0.047	0.002	0.553	0.004	0.476	0.092	0.363
	[0.136]	[0.009]	[0.607]	[0.052]	[0.692]	[0.332]	[0.676]
	{0.080}	{0.010}	{0.970}	{0.035}	{0.940}	{0.378}	{0.866}
Diploma with at most one year delay	0.090	0.000	0.225	0.204	0.582	0.093	0.489
	[0.136]	[0.006]	[0.291]	[0.391]	[0.692]	[0.332]	[0.799]
	{0.124}	{0.005}	{0.716}	{0.657}	{0.975}	{0.378}	{0.940}
Diploma with at most two years delay	0.075	0.001	0.426	0.179	0.794	0.072	0.643
	[0.136]	[0.008]	[0.607]	[0.391]	[0.830]	[0.332]	[1.000]
	{0.109}	{0.005}	{0.935}	{0.597}	{0.985}	{0.303}	{0.980}
Diploma with at most three years delay	0.086	0.002	0.481	0.167	0.918	0.071	0.769
	[0.136]	[0.008]	[0.607]	[0.391]	[0.849]	[0.332]	[1.000]
	{0.124}	{0.005}	{0.965}	{0.552}	{0.995}	{0.303}	{0.990}
Diploma with GPA ⩾8	0.056	0.770	0.010	0.857	0.021	0.076	0.683
	[0.136]	[0.627]	[0.021]	[0.842]	[0.055]	[0.332]	[1.000]
	{0.095}	{0.975}	{0.065}	{0.995}	{0.124}	{0.333}	{0.985}
Science or health fields	0.517	0.704	0.099	0.303	0.581	0.945	0.259
	[0.157]	[0.607]	[0.164]	[0.590]	[0.692]	[1.000]	[0.545]
	{0.682}	{0.975}	{0.433}	{0.811}	{0.975}	{0.990}	{0.781}
Grade retention	0.025	0.010	0.694	0.012	0.733	0.060	0.461
	[0.136]	[0.021]	[0.607]	[0.052]	[0.821]	[0.332]	[0.799]
	{0.055}	{0.065}	{0.975}	{0.075}	{0.985}	{0.289}	{0.940}
Changed school	0.540	0.531	0.189	0.013	0.006	0.876	0.282
	[0.157]	[0.607]	[0.291]	[0.052]	[0.052]	[1.000]	[0.545]
	{0.682}	{0.970}	{0.647}	{0.075}	{0.050}	{0.990}	{0.781}

Note: Each cell reports: (i) the conventional *p*-value corresponding to the results reported in Tables 7 and 8; (ii) in brackets the sharpened *q*-values, which account for the false discovery rate (FDR) (see Anderson, 2008); (iii) in braces the *p*-values controlling for the familywise error rate (FWER) (see Clarke et al., 2020). Both procedures correct for multiple outcomes and multiple (sub)samples.

Table A.10
p-values, FDR *q*-values and FWER *p*-values.

Outcome	Lowest 50% Cito		Highest 50% Cito		Lowest 50% income		Highest 50% income	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Diploma on time	0.004	0.391	0.758	0.144	0.014	0.129	0.126	0.932
	[0.068]	[0.451]	[0.648]	[0.241]	[0.088]	[0.346]	[0.346]	[1.000]
	{0.100}	{0.950}	{0.995}	{0.766}	{0.204}	{0.786}	{0.786}	{1.000}
Diploma with at most one year delay	0.010	0.753	0.011	0.246	0.001	0.025	0.248	0.863
	[0.073]	[0.648]	[0.073]	[0.331]	[0.008]	[0.102]	[0.569]	[1.000]
	{0.169}	{0.995}	{0.204}	{0.915}	{0.035}	{0.313}	{0.975}	{1.000}
Diploma with at most two years delay	0.019	0.941	0.038	0.155	0.001	0.027	0.969	0.538
	[0.080]	[0.661]	[0.098]	[0.241]	[0.008]	[0.102]	[1.000]	[1.000]
	{0.294}	{1.000}	{0.428}	{0.781}	{0.035}	{0.313}	{1.000}	{1.000}
Diploma with at most three years delay	0.023	0.967	0.042	0.155	0.001	0.072	0.969	0.694
	[0.085]	[0.661]	[0.098]	[0.241]	[0.008]	[0.239]	[1.000]	[1.000]
	{0.318}	{1.000}	{0.438}	{0.781}	{0.035}	{0.602}	{1.000}	{1.000}
Diploma with GPA ⩾8	0.430	0.249	0.214	0.008	0.992	0.001	0.906	0.682
	[0.451]	[0.331]	[0.313]	[0.073]	[1.000]	[0.008]	[1.000]	[1.000]
	{0.975}	{0.915}	{0.886}	{0.159}	{1.000}	{0.035}	{1.000}	{1.000}
Science or health fields	0.997	0.043	0.414	0.814	0.547	0.282	0.977	0.090
	[0.661]	[0.098]	[0.451]	[0.661]	[1.000]	[0.604]	[1.000]	[0.278]
	{1.000}	{0.438}	{0.975}	{0.995}	{1.000}	{0.980}	{1.000}	{0.652}
Grade retention	0.027	0.184	0.889	0.296	0.022	0.653	0.576	0.591
	[0.090]	[0.278]	[0.661]	[0.394]	[0.102]	[1.000]	[1.000]	[1.000]
	{0.353}	{0.851}	{1.000}	{0.915}	{0.294}	{1.000}	{1.000}	{1.000}
Changed school	0.017	0.456	0.140	0.004	0.467	0.254	0.723	0.324
	[0.080]	[0.451]	[0.241]	[0.068]	[1.000]	[0.569]	[1.000]	[0.682]
	{0.294}	{0.975}	{0.766}	{0.100}	{1.000}	{0.980}	{1.000}	{0.985}

Note: Each cell reports: (i) the conventional *p*-value corresponding to the results reported in Tables 7 and 8; (ii) in brackets the sharpened *q*-values, which account for the false discovery rate (FDR) (see Anderson, 2008); (iii) in braces the *p*-values controlling for the familywise error rate (FWER) (see Clarke et al., 2020). Both procedures correct for multiple outcomes and multiple (sub)samples.

Table A.11
Impact of attending a single-track academic school by ethnicity.

Outcome	Non-western migrant background	Native or western migrant background
Diploma academic track on time	−0.151	−0.123*
	(0.122)	(0.064)
Diploma academic track with at most one year delay	−0.009	−0.097**
	(0.129)	(0.046)
Diploma academic track with at most two years delay	−0.017	−0.083**
	(0.104)	(0.040)
Diploma academic track with at most three years delay	−0.035	−0.072*
	(0.097)	(0.038)
Diploma academic track with GPA ≥ 8	0.108**	0.045
	(0.055)	(0.031)
Science or health fields	0.109	−0.068
	(0.178)	(0.061)
Grade retention	0.145	0.116**
	(0.142)	(0.052)
Changed school during secondary education	0.119	−0.065
	(0.083)	(0.067)
N	209	899

Note: Each estimate comes from a separate IV regression with winning the admission lottery as instrument for initial enrollment in a single-track academic 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 A.12
Comparing outcomes between different groups.

Outcome	w/ single-track academic school			w/o single-track academic school		p-values		
	Compliers (1)	Always takers (2)	Placed with priority (3)	Compliers (4)	Non-participants (5)	(2) vs (1) (6)	(3) vs (1) (7)	(4) vs (5) (8)
Diploma on time	0.506	0.741	0.670	0.644	0.503	0.000	0.000	0.002
		(0.036)	(0.026)	(0.042)	(0.012)			
Diploma at most 1 yr delay	0.738	0.878	0.821	0.818	0.636	0.000	0.000	0.000
		(0.027)	(0.021)	(0.034)	(0.012)			
Diploma at most 2 yrs delay	0.771	0.905	0.858	0.833	0.660	0.000	0.000	0.000
		(0.024)	(0.019)	(0.033)	(0.012)			
Diploma at most 3 yrs delay	0.772	0.912	0.861	0.833	0.664	0.000	0.000	0.000
		(0.023)	(0.019)	(0.033)	(0.012)			
Diploma with GPA ≥ 8	0.061	0.111	0.073	0.031	0.026	0.060	0.444	0.704
		(0.026)	(0.015)	(0.016)	(0.004)			
Science or health field	0.493	0.582	0.561	0.511	0.466	0.030	0.013	0.317
		(0.041)	(0.028)	(0.044)	(0.013)			
Grade retention	0.427	0.245	0.292	0.295	0.382	0.000	0.000	0.050
		(0.036)	(0.025)	(0.040)	(0.012)			
Changed school	0.222	0.196	0.175	0.246	0.192	0.425	0.024	0.131
		(0.033)	(0.021)	(0.037)	(0.010)			
N	373–396	144–148	317–332	127–134	1546–1663			

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 A.13
Effects of single-track academic schools on obtaining academic-track diploma on time with GPA above different thresholds.

	N	CCM	(1)	(2)
Pre-university diploma with GPA ≥ 8	1069	0.032	0.046	0.055*
			(0.029)	(0.029)
Pre-university diploma with GPA ≥ 8.5	1069	0.008	0.032*	0.032*
			(0.018)	(0.018)
Pre-university diploma with GPA ≥ 7.5	1069	0.095	0.064	0.080*
			(0.043)	(0.043)
Pre-university diploma with GPA ≥ 7	1069	0.237	0.030	0.045
			(0.058)	(0.056)

Note: Each row reports two IV regressions with winning the school admission lottery as an instrument for initial enrollment in a single-track academic 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.

Table A.14
Alternative specifications for GPA for different groups.

Outcome	Boys	Girls	Cito		Income	
			Lowest 50%	Highest 50%	Lowest 50%	Highest 50%
Diploma with GPA ≥ 8	−0.006	0.111**	−0.004	0.147**	0.106**	0.010
	(0.044)	(0.043)	(0.021)	(0.064)	(0.050)	(0.056)
Diploma with GPA ≥ 8.5	0.006	0.040**	−0.010	0.090**	0.047*	0.005
	(0.035)	(0.017)	(0.015)	(0.037)	(0.027)	(0.040)
Diploma with GPA ≥ 7.5	−0.026	0.170**	−0.048	0.275***	0.069	0.100
	(0.059)	(0.068)	(0.051)	(0.090)	(0.058)	(0.070)
Diploma with GPA ≥ 7	0.020	0.054	0.010	0.071	−0.034	0.105
	(0.071)	(0.093)	(0.061)	(0.111)	(0.072)	(0.085)
	536	518	554	500	513	516

Note: Each estimate comes from a separate IV regression with winning the admission lottery as instrument for initial enrollment in a single-track academic school. Relevant (sub)sample is indicated in the column entries, numbers of observations reported in bottom row. 15 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 A.15
Effects of single-track academic schools on obtaining diploma with high GPA, omitting Latin and Old Greek.

Outcome	Full	Boys	Girls	Cito		Income	
	sample			Lowest 50%	Highest 50%	Lowest 50%	Highest 50%
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Diploma with GPA ≥ 8	0.059**	−0.006	0.111**	−0.004	0.147**	0.106**	0.010
GPA based on all subjects	(0.029)	(0.044)	(0.043)	(0.021)	(0.064)	(0.050)	(0.056)
Diploma with GPA ≥ 8	0.086***	0.069	0.092***	−0.005	0.221***	0.091**	0.067
GPA excluding Latin and Old Greek	(0.028)	(0.043)	(0.035)	(0.023)	(0.061)	(0.043)	(0.052)
	1054	536	518	554	500	513	516

Note: Each estimate comes from a separate IV regression with winning the admission lottery as instrument for initial enrollment in a single-track academic school. Relevant (sub)sample is indicated in the column entries, numbers of observations reported in bottom row. 15 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 A.16
Value added estimates including polynomials of Cito score.

Outcome	Single-track academic schools vs. all comprehensive schools with academic-track students			Single-track academic schools with lotteries vs.comprehensive schools with schools with lottery losing students			Single-track academic 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	0.079***	0.056***	0.041**	0.074***	0.050*	0.035	0.063**	0.044	0.030
	(0.021)	(0.021)	(0.021)	(0.026)	(0.026)	(0.025)	(0.031)	(0.029)	(0.029)
Diploma at most 1 yr delay	0.124***	0.107***	0.098***	0.118***	0.102***	0.092***	0.108***	0.100***	0.092***
	(0.017)	(0.017)	(0.016)	(0.021)	(0.021)	(0.021)	(0.027)	(0.027)	(0.027)
Diploma at most 2 yrs delay	0.140***	0.124***	0.116***	0.134***	0.118***	0.110***	0.119***	0.108***	0.104***
	(0.016)	(0.016)	(0.016)	(0.020)	(0.019)	(0.019)	(0.027)	(0.026)	(0.026)
Diploma at most 3 yrs delay	0.144***	0.128***	0.120***	0.139***	0.124***	0.116***	0.126***	0.117***	0.112***
	(0.017)	(0.017)	(0.016)	(0.021)	(0.020)	(0.020)	(0.029)	(0.028)	(0.028)
Diploma with GPA ≥ 8	0.053***	0.046***	0.041***	0.052***	0.045***	0.039***	0.048***	0.040***	0.033***
	(0.010)	(0.010)	(0.010)	(0.011)	(0.010)	(0.010)	(0.013)	(0.012)	(0.011)
Science or health field	0.067***	0.055**	0.046**	0.064***	0.053**	0.045*	0.047	0.038	0.033
	(0.021)	(0.022)	(0.021)	(0.024)	(0.024)	(0.024)	(0.029)	(0.029)	(0.028)
Grade retention	−0.001	0.016	0.030	−0.007	0.012	0.026	0.001	0.019	0.033
	(0.021)	(0.021)	(0.020)	(0.026)	(0.025)	(0.025)	(0.031)	(0.030)	(0.030)
Changed school	0.036**	0.046**	0.054***	0.013	0.021	0.029	0.012	0.022	0.032
	(0.017)	(0.018)	(0.018)	(0.022)	(0.022)	(0.022)	(0.027)	(0.027)	(0.027)
N	4430	4430	4430	3099	3099	3099	3099	3099	3099
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 a single-track academic school. All columns include the controls listed below Table 3. Columns (1) to (3) are based on all students that enrolled in the academic 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 single-track academic 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.

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