Social networks, elite education and intergenerational mobility

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Abstract

This paper examines the role that social interactions during high school play in driving the stark socio-economic inequalities in elite education that exist in most developed countries. Using administrative data from Norway and exploiting within school, between cohort variation in high school peer characteristics, we find that exposure to peers whose parents are elite educated ('elite peers') promotes elite educational attainment among all students, but exacerbates socio-economic inequalities therein. We show that this detrimental effect on inequalities is due to two main factors. First, the presence of elite peers penalizes the GPA of low SES students, most likely because teachers adjust their grading behavior to the detriment of low SES students. Second, interactions with elite peers encourages high SES students to apply to an elite degree much more than it encourages low SES students. We provide evidence suggesting that the aspirations evoked by elite families may be too far from low SES students' current experiences to give them an incentive to apply to elite degrees even if they have the ability to do so.

Keywords: Peers, Elite education, Subject choice, Social mobility
JEL codes: I22, I24

1 Introduction

Despite large increases in higher education completion rates over the past half century, income segregation in post-secondary education remains pervasive in most countries. Children from higher socio-economic backgrounds are more likely to go to university than children with lower socio-economic backgrounds, and conditional on going to university they are also more likely to attend highly selective or 'elite' institutions. In the US for example, children whose parents are in the top 1% of the income distribution are 77 times more likely to attend an Ivy League college those whose parents are in the bottom 20% (Chetty et al., 2020). But this phenomenon is not limited to countries with low income mobility, like the US and the UK (Britton, Drayton and van der Erve, 2021; Heckman and Landersø, 2021; Landerso and Heckman, 2017). In Norway, a country notorious for its high income mobility (and the setting of this study), youth with at least one elite educated parent are five times more likely to enroll in an elite degree[1] than youth whose parents have the compulsory level of education (Bütikofer, Risa and Salvanes, 2021).

This paper examines the role of social networks as a driver of intergenerational persistence in elite education. Specifically, we ask whether exposure to peers from elite educated families (elite peers henceforth) during high school enhances or hinders students' chances to enroll in an elite degree. We analyze whether and why this effect differs between students from different socio-economic (SES) backgrounds and what implications this has for intergenerational mobility. Answers to these questions can help assess the effectiveness of policies, such as transportation subsidies and merit-based high school selection mechanism, which aim to reduce educational inequalities by reducing the social stratification of high schools.

In Norway, students wishing to pursue a post-secondary education select a set of degrees they wish to apply to during their last year of high school. Admission decisions are then centralized based on students' selection and high school GPA. There are therefore two broad channels through which high school peers can influence the decision to pursue an elite education: by affecting GPA and/or by affecting student's intentions to apply, conditional on GPA. The large empirical literature on academic peer effects suggests that elite peers may influence high school grades, but suggests that

[1] In Norway elite degrees are defined as a set of highly selective degrees, defined by a particular subject and institution. We provide the exact list in section 2 of the paper.

these effects could be heterogeneous across the distribution of student's ability and hence between students from different socio-economic backgrounds. The evidence so far is mixed with respect to the exact shape of these effects and the mechanisms underlying them (de Gendre and Salamanca, 2020; Feld and Zoelitz, 2017; Lavy, Paserman and Schlosser, 2011; Tincani, 2017), making it *a priori* unclear how exposure to elite peers would affect high school grades and SES gaps therein.

The second channel through which elite peers may affect students' decision to enroll in an elite degree is by affecting their intention to apply, conditional on grades. Recent evidence shows that different SES backgrounds have been shown to hold different subjective beliefs about the returns to post-secondary education and argue this could explain why similarly achieving low SES students are less likely than high SES counterparts to pursue elite education (Boneva, Golin and Rauh, 2021; Has et al., 2021; Hastings et al., 2016). Interactions with elite peers and their families could help reduce these frictions by correcting students' beliefs about the returns to these degrees and/or their chances to be admitted. The salience of this channel could vary between students from different SES backgrounds, for example if low SES students are less likely to befriend elite peers than their high SES peers to and/or if they do not believe these outcomes to be attainable (Ray, 2006).

The contribution of this paper is to provide the first empirical evidence on the role of elite peer effects in explaining socio-economic inequalities in elite education and to present extensive analysis of the underlying mechanisms. We do so in the context of Norway, where these inequalities are stark and where the data and institutional context provide a unique opportunity to study this question. Norwegian register data links the education and labor market records of students to those of their parents, high school peers and peers' parents for all high school students. This allows us to estimate the shape of elite peer effects with precision and to map the long-term implications of our results for integenerational income mobility. Moreover, education is free in Norway, making credit constraints a much less salient factor than in countries, such as the US and the UK, where elite degrees are very expensive (Lochner and Monge-Naranjo, 2012). The data also contains measures of middle school academic performance, which we use to control for prior ability gaps between low and high SES students, another important explanation for SES inequalities in higher education (Carneiro and Heckman, 2002; Caucutt, Lochner and Park, 2017).

The paper is essentially organized in four parts. First, we estimate the overall or 'reduced form' effect of belonging to a cohort with a higher fraction of peers with elite educated parents in high

school on the probability of enrolling in an elite degree. We follow Bütikofer, Risa and Salvanes (2021) in defining elite degrees as a widely recognized set of highly selective degrees leading to high paying occupations in Norway.[2] Our identification strategy exploits within school, between cohort variation in peer composition, a strategy that was proposed by Hoxby (2000) that has been extensively used subsequently (among others, Angrist and Lang, 2004; Black, Devereux and Salvanes, 2013; Cools, Fernández and Patacchini, 2019; Lavy, Paserman and Schlosser, 2011). We perform an extensive set of robustness checks to probe the validity of our identifying assumption in our context.

Our first finding is that while being exposed to elite families during high school has a positive effect on the average student's likelihood to enroll in an elite education, the benefit is three times larger for students with at least one elite educated parent (high SES) than it is for students with low educated parents (low SES). This implies that reducing the stratification of high school pupils based on parental education would not only increase the proportion of first generation elites, but also increase the intergenerational persistence in elite education.

In the second part of the paper, we explore the extent to which this result is driven by an effect of elite peers on GPA vs. an effect of elite peers on the decision to apply for an elite degree (conditional on GPA). Using the same identification strategy as in the first part of the paper, we first establish that increased exposure to elite peers has no effect on the GPA of high SES students, but *decreases* the GPA of low SES students. We then quantify the size of the direct effect of elite peers on the decision to apply to an elite degree conditional on GPA. In doing so, we account for the fact that GPA is endogenous to individual elite degree enrollment and instrument GPA by exploiting a unique feature of the Norwegian examination system whereby schools randomize the subjects students are externally-assessed (as opposed to being teacher assessed).[3] Our estimates imply our second main finding: about half of the SES gap in the overall effect of elite peers on elite degree enrollment is driven by a direct effect on students' intentions to apply while the other half

[2]Examples are master degrees in law, medicine, and economics at the University of Oslo, economics and business administration at the Norwegian School of Economics, or engineering at the Norwegian University of Science and Technology. Bütikofer, Risa and Salvanes (2021) documents the high returns to elite education by showing how these educations feed into top occupations and high salaries. We further show in this paper that those returns are equally high for low and high SES children, an important different from other contexts where such returns have been studied (Britton, Dearden and Waltmann, 2021; Zimmerman, 2019). See section 7.

[3]In essence, this is equivalent to a mediation analysis of the overall effect of elite peers on elite degree enrollment taking into account that the mediator (high school GPA) is endogenous (Celli, 2021).

is driven by the indirect effect of elite peers on GPA.

Third, we further characterize the behavioral mechanisms underlying the positive direct effect of elite peers on educational intentions and the negative indirect effect of elite peers on GPA for low SES students. First, we show that the direct elite peer effects is higher among students who live in areas with greater levels of upward mobility. This results suggests that, conditional on GPA, one reason why low SES students' decisions to enroll in an elite degree are less sensitive to the influence of their elite peers is because pursuing an elite degree is less likely to be within their aspiration window. Second, we investigate into the negative effect of elite peers on GPA for low SES students by looking at the effect of elite peers separately on exams graded by a blind examiner vs. exams graded by the student's teacher. We show that the effect of elite peers on externally assessed exams is positive, while it is negative for teacher assessed exams. We argue and present additional evidence that this result most likely reflects the fact that teachers are more likely to adjust their grading behaviour to the detriment of low SES students when the proportion of elite peers in the school increases.

We conclude the paper by discussing the long-term implications of our results for intergenerational *income* mobility. To do so, we use data on the earnings of the five oldest cohorts in our dataset, who have acquired several years of post-graduate labour market experiences by 2018, our last year of data. First, we show that the returns to an elite degree is high and not statistically different for low and high SES students in Norway. This pattern, which we believe had not been uncovered before, is important because it underlies the potential to reduce interegenerational inequalities by increasing the enrollment of low SES students in elite degree in Norway. It is also noteworthy as it comes in stark contrast with Zimmerman (2019) and Britton, Dearden and Waltmann (2021) who find large differences in the returns to elite degrees by socioeconomic background in Chile and England, respectively. We further show that high school elite peers increases log earnings and earnings rank at age 28-32, but as with elite degree enrollment this effect is larger among high SES students than among low SES students.[4] Accordingly, exposure to elite peers in high school exacerbates intergenerational income mobility, suggesting that social interactions may be a core explanation for why intergenerational income mobility, which is fairly high and constant through most of the income distribution in Norway, significantly dips at its upper tail (Pekkarinen,

[4]Earnings rank is fairly stable after age 28-30, making it a good outcome to run this analysis.

Salvanes and Sarvimaki, 2017).

The rest of the paper is organised as follows. Section 2 provides some background information on the education system in Norway. Section 3 describes our data. In Section 4, we discuss our empirical strategy to identify the effect of elite peers on elite degree enrollment and presents these benchmark findings. Section 5 focuses on decomposing this overall effect into an effect of elite peers on GPA and an effect of elite peers on elite degree enrollment conditional on GPA. Section 6 presents a series of results to suggest possible behavioral mechanisms underlying these effects. In Section 7, we map the long-term implications of these results for earnings and intergenerational income mobility in Norway. Section 8 concludes.

2 The Norwegian Education System

Norwegian education has been compulsory until the age of 16 since 1959; all students must complete 6 years of primary school followed by 3 years of middle school (Black, Devereux and Salvanes, 2005). After completing these 9 years of education, students decide whether to continue their education in high school or to drop out to join the labor force. Those who continue onto high school choose between an academic track and a vocational track. The academic track, which we focus on in this paper, lasts 3 years and is geared towards preparing students to attend higher education.

Assignment of students to high schools varies across counties. In some counties (including all rural counties), schools have catchment areas and geographical distance is largely determine student high school choice. Other counties have a free high school choice system where intake is centralized and based on the middle school GPA. Middle school GPA is a weighted total of all teacher-awarded grades, combined with the grades from written and oral exams in randomly drawn subjects.[5]

Higher education institutions include universities, scientific schools, and university colleges. Since the early 2000s, Norwegian universities and scientific schools offer three-year bachelor degree and five-year combined bachelor-master degrees. 98% of students attend a public institution, and even private institutions are funded and regulated by the Ministry of Education and Research.

[5]Eight out of 19 counties had free school choice in our data period. Importantly, the most densely populated areas have free school choice including the large cities, which means that the majority of high school students had free school choice in our period of analysis. Some counties have changed their assignment systems over recent years. For example, the two largest cities in Norway - Oslo and Bergen - have varied their intake systems over recent years (Bütikofer et al., 2020).

There are generally no tuition fees for attending a public higher education in Norway, and most students are eligible for financial support (part loan/part grant) from the Norwegian State Educational Loan Fund.

To pursue a higher education, students must apply for a combination of a field of study at a specific institution (e.g. law at the University of Oslo). Whereas 'elite' higher education in the US refers to attending highly competitive, private institutions with high tuition fees, in Norway 'elite education' is described as completing specific degrees at specific institutions that yield the best earnings outcomes. Those degrees are all five-year masters degrees in a select set of subjects at specific universities. Specifically, they include master degrees in law, medicine or economics at the University of Oslo, masters in economics and business administration at the Norwegian School of Economics, and master degrees in engineering at the Norwegian University of Science and Technology.

Since the late 1990s, admission to public higher education institutions has been centralized and is entirely based on high school GPA. Like middle school GPA, high school GPA is a combination of teacher-assessed internal grades and external oral and written exam grades. All high school students must take several mandatory exams. In their first year, 20 percent of students sit for a final exam in one course. In their second year, all students sit for a final exam in one course, either oral or written. In their third year, all students take four exams: one written exam in Norwegian language, final written exams in two subjects and a final oral exam in one subject (Andersen and Lokken, 2020). It is the responsibility of each county to decide which topic students at each school are tested by exams (except the ones that is mandatory for all students like Norwegian in the third year). As described in detail in Andersen and Lokken (2020), the exams taken in each school depends on which topic and combination of topics chosen by students in each school. This means that which topic the students are tested in varies both across schools and over years. Andersen and Lokken (2020) find strong support for this to be a random process.

Like in the US, access to these degrees is highly competitive, but an important difference is that, just like all the other degrees, those elite degrees have no tuition fees. Moreover, legacy students have no easier access to these degrees than other students as admission is solely based on high school GPA. As we show in the next section however, despite these equalizing features of the higher education system in Norway, there is a very strong socioeconomic gradient in the likelihood

to pursue a higher education and an even stronger one in the likelihood to pursue an elite degree. This paper aims to better understand the role of social networks in high schools play in driving these inequalities.

3 Data and descriptive statistics

Our data comes from Norwegian register and administrative data that have been linked by Statistics Norway. We select our sample to include all students finishing middle school and entering high school in Norway between 2002 and 2012. These linked data allows us to follow these students from middle school through to high school and university (if they ever enroll). We observe the type of higher education degree they enroll in and use this information to define elite degrees as the set of 5-year bachelor/masters degree in law, medicine, and STEM obtained in the best institutions of the country.[6] We define our main outcome variable Y_{isc} as an indicator for whether student i entering high school s in cohort c enrolls into an elite degree within six years of completing middle school.

Our dataset contains school identifiers and links students' educational records to a rich set of information on their parents, including parental education, occupation and income. With these data, we construct individual-level controls to include in our specification, as well as our main treatment variable, P_{-isc}, the proportion of parents who have an elite education in the student i's cohort c in high school s (excluding student i's own parents).

Table 1 provides summary statistics for the individuals in our sample. Our sample has close to 178,000 students studying in 557 high schools spread throughout Norway. High school students are disproportionately female (60%) and selected on family income, with 25% of their families have income in the top 10% of the income distribution. They are also selected on ability: the average middle school GPA in the sample is 0.67 standard deviation above the GPA of the average middle school students (we standardized the middle school GPA distribution to have mean zero and standard deviation 1 in each full cohort of middle school students).

[6] Data on education comes from the national education database, which contains codes for the highest completed level of education. These codes are in the NUS2000 format, which is a six-digit code containing highly detailed information on both the level and field of a person's education. The elite programs are defined as degrees at the master level (or above) in law, medicine, economics, economics and business administration at the Norwegian School of Economics or engineering at the Norwegian University of Science and Technology.

As mentioned earlier, most students in the academic track attend a higher education institution, but only one in ten pursue an 'elite' degree, reflecting their high selectivity. Among them, close to 7% complete a 5-year STEM or Economics/Business masters degree, while 2% complete a law masters degree and 1% complete a medical degree. Although Norway has one of the lowest intergenerational income elasticities in the world, intergenerational education persistence is high and comparable to levels in other countries, such as the US, with much lower levels of income mobility. Bütikofer, Risa and Salvanes (2021) document that this persistence is particularly high at the top of the education distribution, a pattern we replicate in our sample.

To explore the link between parental and child education descriptively in our sample, we distinguish between two groups of children with different socio-economic status, based on the education of their parents. We define the first, 'low SES' group of children as those children with at least one with no further education beyond compulsory education (10 years of education) and no parent with an elite education. The second, 'high SES' group, is the group of children with at least one parent with an elite education (and no parent with no further education beyond compulsory education).

Table 1 compares the probability of enrolling in a higher education degree across the low and high SES groups and confirms the existence of a parental education gradient, with the likelihood of enrolling in higher education going from 86% among children in 'low education' households to 95% among children in the 'elite education' households. The gradient is much more pronounced when it comes to enrolling in an elite degree, with the probability of enrolling being five times as large high SES households than among low SES ones. These patterns are roughly similar across different types of elite degrees, with the exception of medical degrees where high SES children are 7 times as likely to enroll in a medical degree than low SES children.

Table 1: Summary statistics of the sample

	Full sample	Low SES sample	High SES sample
	Mean	Mean	Mean
Enrolls in higher education	0.904	0.861	0.956
Enrolls in elite degree	0.102	0.053	0.260
Proportion of parent with elite degree	0.061	0.047	0.100
	(0.056)	(0.047)	(0.068)
Female	0.601	0.651	0.527
Born in Norway	0.873	0.836	0.852
Middle school GPA (std)	0.676	0.496	0.921
	(0.634)	(0.639)	(0.591)
Mother's highest education level			
Compulsory education	0.516	0.932	0.161
High school degree	0.126	0.068	0.144
University degree	0.358	0.000	0.695
Father's highest education level			
Compulsory education	0.578	0.916	0.073
High school degree	0.139	0.084	0.042
University degree	0.282	0.000	0.885
Proportion of own parents with an elite degree	0.066	0.003	0.580
	(0.194)	(0.038)	(0.183)
Family income in the top decile	0.214	0.123	0.485
	(0.309)	(0.244)	(0.352)
Average peer middle school GPA (std)	0.427	0.299	0.613
	(0.496)	(0.541)	(0.399)
Peer mean parent income (KRN)	821,326	768,646	958,338
	(325,105)	(270,580)	(470,169)
Peer mean parent in to income decile	0.247	0.230	0.308
	(0.110)	(0.103)	(0.120)
High school GPA (std)	0.013	-0.252	0.494
	(0.999)	(0.951)	(1.000)
N	177,219	58328	20,018

Notes: Sample of students ending middle school and entering high school between 2002-2012. The table presents means and standard deviations (in parentheses) of the main variables used in the analysis. High school GPA is standardized to have mean 0 and standard deviation 1 across all children entering high school in our sample. Middle school GPA is standardized to have mean 0 and standard deviation 1 within the whole population cohort.

4 The overall effect of elite peers: identification and results

4.1 Identification strategy and econometric specification

We start the analysis by estimating the 'overall' or reduced form effect of exogenously increasing P_{-ics}, the proportion of elite educated parents in student i's high school cohort. By 'overall' effect, we mean that we do not control for any other characteristic of peers that may be correlated with it. We operationalize this strategy by estimating the following benchmark specification by OLS:

$$Y_{isc} = \beta_1 P_{-ics} + X_{ics}^{'}\beta_2 + \alpha_s + \rho_c + \epsilon_{ics} \tag{1}$$

where Y_{isc} is indicator for whether student i in school s and cohort c enrolls in an elite degree within 6 years of graduating from middle school; P_{-ics} measures the proportion of cohort-school peers' parents who have an elite degree; X_{ics} is a vector of student i's characteristics (gender, middle school GPA, mother and father's education, and family income); α_s is a school indicator; ρ is a cohort effect; and ϵ_{ics} is an error term. We cluster standard errors at the school level to account for unobserved correlated of error terms within schools.

In equation (1), the parameter of interest is β_1, and OLS estimates will be unbiased if P_{-ics} is uncorrelated with unobserved determinants of the student's achievement (conditional on the controls included in the model). For (1) to yield valid causal estimates of the parameter of interest, the key identifying assumption is therefore that cohort-to-cohort variation in the proportion of elite educated parents in random within school. This assumption is likely to hold given the rules that govern admission into high school in Norway. As discussed in Section 2, admission was based on middle school GPA for most students in our sample, though it was based on the student's distance to the school in a small number of mostly rural schools. In GPA-based admission schools, variation in P_{ics} comes from year-to-year variation in the education of parents of students whose middle school grade are high enough to be admitted into a certain school. The design therefore assumes that such variation is idiosyncratic, conditional on the student's middle school GPA. In the small number of mostly rural schools, admission is based on catchment area, and in these schools year-to-year variation in the proportion of parents with an elite degree in a given school results from year-to-year variation in the composition of families living in the area.

This strategy therefore allows families to select their children's high school based on their knowledge of the composition of the school. However, as explained in Hoxby (2000), the strategy relies on the idea that there is some variation in adjacent cohorts' peer composition within a school that is idiosyncratic and beyond the easy management of parents and schools. That is, "even parents who make very active decisions about their child's schooling cannot perfectly predict how their child's actual cohort within a school will turn out" (Hoxby, 2000). Moreover, here we focus on idiosyncratic variation in cohort composition, as opposed to classroom composition, so we need not worry about schools and parents manipulating the assignment of students to classrooms.

There are two main potential concerns with this identification strategy. The first one is whether there is enough variation in parent peer composition across cohorts within schools to obtain precise estimates of our parameter of interest. The standard deviation of our treatment variable is 0.056 in the raw data and reduced by less half to 0.026, once we remove school and cohort effects. All our estimates are very precisely estimated. The second potential concern with this identification strategy arises if families select high schools based on school trends rather than levels. If highly educated parents move closer or encourage their children to apply to schools with outcomes on an upward trend (say because of better management or new teachers), then the proportion of elite educated parents P_{-ics} will be correlated with time-varying unobserved inputs driving such trends in outcomes ϵ_{ics}, and the parameter β_1 will confound the causal effect of elite educated parents P_{ics} with the effect of these unobserved inputs.

To gauge the severity of this second issue, we perform a number of checks. First, we perform a series of placebo tests checking directly whether the within-school variation in the proportion of elite educated parents is associated with changes in the characteristics of students in the cohort. For these placebo checks, we specifically pick characteristics, such as birth outcomes, which cannot be causally affected by peers but which are likely to be correlated with the unobserved characteristics of other students selecting in the same schools. The fact that we find no significant correlation between these characteristics of students and the proportion of elite families in the school (conditional on school and cohort fixed effects) is suggestive that our treatment variable is unlikely to be correlated with other unobservable, individual determinants of achievement.

Second, we re-estimate our main model in equation (1) including school-specific linear trends. If the results from our main model are similar to one where outcomes are allowed to vary within

schools (linearly), we will gain reassurance that β_1 is indeed capturing the marginal effect of P_{-ics} rather than that of time-varying unobservable determinants of the outcome variable, which could arise if families are selected into high schools based on trends in achievement (as opposed to levels).

A limitation of this second test if that it assumes that time trends may not be well captured by the linear term. We therefore perform a third robustness check, first proposed and named 'drop by mother than random' in Hoxby (2000). This check consists in dropping schools where within school, between cohort variation in P_{-ics} is greater than what would be observed if such variation was random and re-estimating equation (1) on the reduced sample of schools. The estimates of our main specification are very similar, providing reassuring evidence that our identifying assumption holds in this context.

4.2 Benchmark results

The estimates of equation 1 for the full sample are reported in Column (1) of Table 2. Across all students, exposure to elite social networks significantly increases average students' enrollment in elite education. A one standard deviation (SD) increase in the proportion of elite educated parents in a school-cohort leads to a 2.6 percentage point increase in the likelihood of students in this school-cohort to enroll in an elite degree. This effect is highly statistically significant, and its magnitude is also economically significant. For example, it is comparable to the association between having a university educated fathers (relative to having a father with compulsory level of education) and elite degree enrollment (see Appendix Table A.1, which reports the estimates of coefficients associated with control variables in this benchmark specification).

Table 2: Effect of elite peers on the probability of enrolling in an elite degree

	(1) Full sample	(2) Low SES	(3) High SES
Proportion of parents with elite degree (std)	0.026***	0.013***	0.040***
	(0.003)	(0.003)	(0.008)
Number of pupils	177,219	58,328	20,018
Number of schools	556	524	459

Notes: Data source, Norwegian administrative data. Sample of students ending middle school and entering high school between 2002-2012. OLS estimates of a regression of an indicator for whether the student is enrolled in an elite degree within 6 years of starting high school on: the proportion of parents with elite degree in the student's school's cohort, student's gender, middle school GPA, an indicator for whether the student was born in Norway, mother and father's highest education level, an indicator for whether the student's own parent have an elite education, and an indicator for whether the student's family income is in the top decile of the overall income distribution. All models also include cohort and school fixed effects. Column (1) reports the coefficient on the proportion of parents with an elite degree estimated in the full sample, column (2) and column (3) report the same coefficient estimated in the low SES and high SES samples, respectively. The low SES sample is defined as the group of students who have at least one parent with no more than the compulsory level of education, but no parent with an elite education. The high SES sample is defined as the group of students who have at least one parent with a post-secondary education, but no parent with a compulsory level of education. Standard errors clustered at the school level. *** p<0.01, ** p<0.05, * p<0.1

Columns (2) and (3) of Table 2 reports the estimates of β_1 in the benchmark model in the samples of low SES and high SES students and show that the effect of elite peers in one's high school cohort is three times larger for high SES students than it is for low SES students (4 ppts vs 1.3 ppts). Both effects are statistically significant from zero and significantly different from each other. Combined with the summary statistics presented in Table 1, these results indicate that low SES students face a double disadvantage: not only are they exposed to a smaller share of elite peers in their school cohort than high SES children are on average, but being exposed to elite peers is also less beneficial to their future educational outcomes than it is for high SES children.

Table 3: Oaxaca Binder decomposition of the SES gap in elite degree enrollment

	Contribution of gap in mean characteristics	Contribution of SES gap in coefficients
Proportion of parents with elite degree	-0.015***	-0.010***
	(0.002)	(0.003)
Female	-0.008***	0.040***
	(0.000)	(0.004)
Student is of Norwegian origin	0.000***	-0.035***
	(0.000)	(0.007)
Student's middle school GPA	-0.050***	-0.140***
	(0.001)	(0.005)
Proportion of student's own parent with an elite degree	-0.116***	0.022***
	(0.011)	(0.003)
Student's parents are in top income decile	-0.007***	-0.013***
	(0.002)	(0.003)
Mother's highest education level (ref = compulsory level)		
High school	-0.001***	-0.003**
	(0.000)	(0.001)
University	-0.013***	0.007**
	(0.005)	(0.003)
Father's highest education level (ref = compulsory level)		
High school	0.000***	0.001
	(0.000)	(0.001)
University	-0.038***	0.020***
	(0.008)	(0.006)
SES gap in enrollment in elite degree	-0.207***	
	(0.003)	

Notes: This table reports a selected set of results from the Oaxaca decomposition of the gap in elite degree enrollment between the high SES and low SES groups of students, using estimates of the benchmark model shown in Table 2. Dependent variable is indicator for studying for an elite (graduate) degree in STEM, medicine or law. Model controls for student Norwegian born, gender, middle school GPA, mother and father education and income in year before high school entry and fixed effects for school and year. Standard errors clustered at school level.

To measure the contribution of these two sources of disadvantage to the SES gap in elite education enrollment, we perform an Oaxaca Binder decomposition of the gap in elite education enrollment between low and high SES students. This decomposition uses the estimates of the benchmark model to compute the contribution of the average SES gap in the explanatory variables of the model and the contribution of the SES gap in coefficients associated with these variables to the SES gap in elite degree enrollment.[7] The results of the decomposition are reported in Table 3. Remember that the overall SES gap in the probability of elite degree enrollment is 20.7 percentage

[7]We are using the coefficients estimated in the sample pooling both low and high SES children when calculating the contribution of gaps in average characteristics to the average SES gap in elite degree enrollment.

points (ppts). The SES gap in the average share of elite educated parents in high school explains 1.5 ppts or 7.25% of the SES gap in elite degree enrollment. The SES gap in the effect of students' exposure to elite educated families explains 1 ppt or 4.8% of the SES gap in the outcome.

To get a sense of how important exposure to elite networks are in explaining the SES gap in elite degree enrollment, we also present the results of the decomposition for a selected set of covariates included in the model. For example, the SES gap middle school GPA explained 0.050 ppts or 25% of the SES gap in elite degree enrollment. The strongest predictor of whether a student enrolls in an elite enrollment is whether or not their parents have an elite education. The SES gap in this variable (which is 0 in the low SES group by construction) explains about half of the elite degree enrollment. This is also important to suggest that increasing the elite enrollment of low SES students could have intergenerational consequences for educational inequalities.

4.3 Checks on the validity of the identification strategy

As discussed in section 4, we perform three checks to probe the validity of our identification strategy. First, we estimate our main model, this time with student's birth outcomes as outcome variables. The results of these placebo checks are reported in Table 4 and show that the proportion of elite families in high school is unrelated to any of the student's birth outcomes. This is an encouraging indication that our treatment variable is unlikely to be correlated with unobserved student characteristics which could affect their educational outcomes.

We then re-estimate our main specification, this time also including school-specific linear trends. That is we estimate the following specification:

$$Y_{isc} = \beta_1 P_{-ics} + X'_{ics}\beta_2 + \alpha_s + c \times D_{is} + \rho_c + \epsilon_{ics} \tag{2}$$

where c is a cohort (linear) trend and D_s is an indicator for whether the student is in school s. The results of this specification are reported in Panel A of Table 5 and show estimates that are very similar to those from our benchmark specification (included in the first column of the table for easy comparison).

The final check that we perform is the 'Drop if not random' check proposed and implemented in Hoxby (2000), whereby we re-estimate the model on the sample of schools for which the cross-

Table 4: Placebo tests - Effect of elite peers on child birth outcomes

	Coefficient (Standard error)	Number of students	Number of schools
Outcome variables:			
Child birth weight	-3.011	169,864	554
	(3.474)		
Low birth weight	-0.000	177,219	556
	(0.001)		
Gestation	-0.011	157,669	552
	(0.012)		
Height	-0.010	164,073	551
	(0.015)		
Head circumference	0.005	167,949	553
	(0.009)		
Congenital malformation	-0.000	170,133	554
	(0.001)		
Severe deformity	-0.001	170,133	554
	(0.001)		
Norwegian born	-0.000	177,219	556
	(0.000)		

cohort variation in the proportion of elite families across cohorts appear random. The estimates of the model on this sample are reported in Panel B of Table 5 and are very similar to those obtained on the whole sample (reported in Table 2). Overall, this evidence provides strong confidence in the validity of our empirical strategy.

4.4 Non-linearities

Several papers in the peer effects literature find evidence of heterogeneity in peer effects. For example, Feld and Zoelitz (2017) find that while students benefit from better peers on average, low-achieving students are harmed by high-achieving peers. Lavy, Paserman and Schlosser (2011) find that the proportion of low achieving peers has a negative effect on the performance of regular students, especially those located at the lower end of the ability distribution. Tincani (2017) estimates peer effects as a flexible function of the variance in peer ability and finds evidence of substantial heterogeneity in the size and even in the sign of such effect across the distribution of variance.

In this paper, we have shown that the effect of the proportion of parents with an elite degree is

Table 5: Robustness checks for the effect of elite peers on the probability of enrolling in an elite degree

	(1) Full sample	(2) Low SES	(3) High SES
A - Including school linear trends			
Proportion of parents with elite degree (std)	0.027***	0.014***	0.047***
	(0.003)	(0.003)	(0.008)
Number of pupils	177,219	58,328	20,018
Number of schools	556	524	459
B - 'Drop if not random'			
Proportion of parents with elite degree (std)	0.022***	0.010**	0.038***
	(0.004)	(0.004)	(0.013)
Number of pupils	83,465	28,181	8,420
Number of schools	313	284	240
C - Non-linearities			
Proportion of parents with elite degree (std)	0.024***	0.014***	0.058***
	(0.003)	(0.003)	(0.010)
Proportion of parents with elite degree - squared	0.001	-0.001	-0.008**
	(0.002)	(0.001)	(0.004)
Number of pupils	177,219	58,328	20,018
Number of schools	556	524	459

significantly different between low and high SES. However, one may argue that the SES difference in the peer effect we consider is in fact driven by non-linearities in the peer effect. Specifically, given that low SES students are, on average, less exposed to elite families in their high school, the presence of increasing marginal returns to being exposed to elite families in high school could lead us to estimate a higher average treatment effect for the high SES group than for the low SES group.

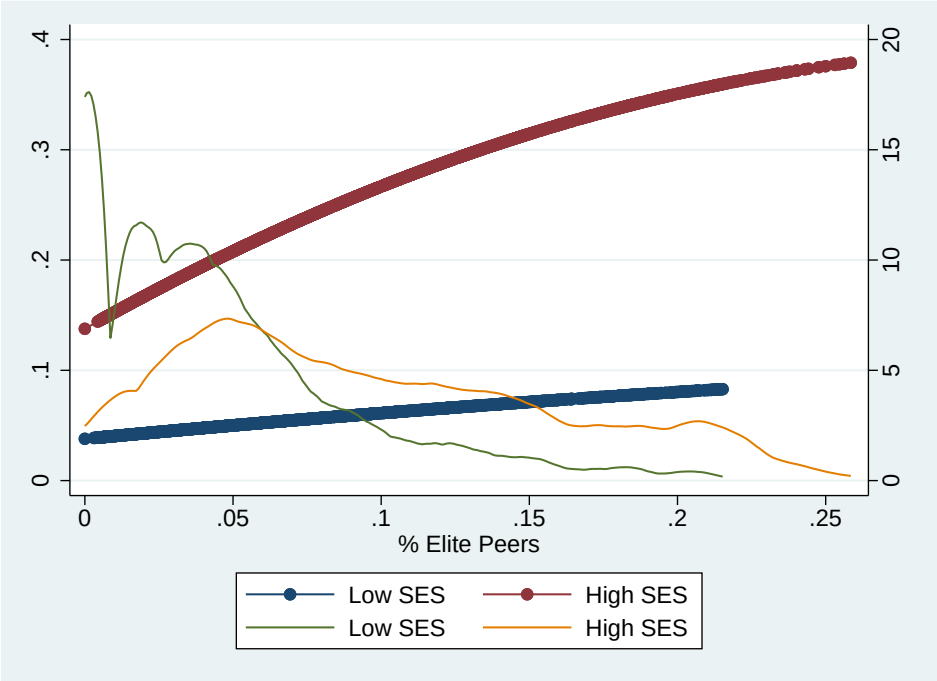
We test whether this is the case by re-estimating our main model, this time allowing the effect of elite families to enter quadratically. That is we estimate the following specification:

$$Y_{isc} = \beta_{11} P_{-ics} + \beta_{12} P_{-ics} \times P_{ics} + X'_{ics}\beta_2 + \alpha_s + \rho_c + \epsilon_{ics} \tag{3}$$

The estimates of the coefficients β_{11} and β_{12} are reported in Panel C of Table 5. There is little

evidence of non-linearities in the effect of the proportion of elite families on students' outcomes, except for the high SES group where the coefficient on the square of our treatment variable is negative and statistically significant. In Figure 1, we plot the marginal effect of the proportion of elite families as well as the density of the treatment variable for the low and high SES samples to check for common support across the two samples. Across the distribution of proportion of elite families, the peer effect is higher for elite students, which confirms that the significant SES difference in the effect of elite peers on elite degree enrollment is not driven by non-linearities in the effect of elite peers.

Figure 1: Marginal effect of exposure to elite social networks implied from quadratic specification



Notes: This graph plots the densities of P_{-ics} in the low SES (green) and high SES samples (orange) and the marginal return to an increase in P_{-ics} as a function of P_{-ics} implied by estimates of β_{11} and β_{12} in equation (3).

5 Elite peer effects on students' GPA and application intentions

Having established that elite peer effects are stronger for high SES than low SES students, we turn to exploring the mechanisms underlying this result. As explained in section 2, whether a student enrolls in an elite degree (our outcome variable) is based on two main determinants: a) the student's

high school GPA and b) whether the student applies to this elite degree, conditional on GPA. Elite peers may affect both a) and b), and we start exploring the mechanisms underlying our benchmark results by disentangling the extent to which elite peers affect high school GPA versus the extent to which elite peers affect elite degree enrollment conditional on GPA. For expositional ease we call the effect on elite enrollment through an effect on GPA the indirect effect of elite peers, and the effect conditional on GPA the direct effect.

5.1 Elite peer effects on GPA

We first estimate the causal effect of elite families on high school GPA. To do so, we re-estimate our main equation (1) with overall high school GPA (standardized to have mean 0 and standard deviation 1 within each cohort) as outcome. The results of this specification are reported in the first 3 columns of Panel A of Table 6. Overall, belonging to a cohort with a higher proportion of elite peers has a negative and statistically significant effect on GPA. This effect is four times as negative for low SES students as it is for high SES students.

This specification can be seen as a variant of the many specifications estimated in the academic peer effect literature, which regress a student's measure of academic achievement on a peer characteristics measured in the past (as well as other controls to help deal with the endogeneity problem of the peer characteristic). A common empirical specification is the linear-in-means, focusing on the average of the peer characteristic in the relevant unit (school, classroom, etc.), though several theoretical and empirical papers argue its inadequacies. Studies, such as Hoxby and Weingarth (2006), Tincani (2017) and Booij, Leuven and Oosterbeek (2016) provide strong empirical evidence providing that other moments of the distribution of the peer characteristic but the mean have important effects on student achievement.

Within this context, our treatment variable - the proportion of elite peers in the student's cohort - can be seen as potentially measuring different aspects of the peer student's ability distribution. Given the high correlation between parental education and student ability, we would expect elite peers to be, on average, high achievers. As a result, a marginal increase in the proportion of elite peers would not only raise the average of peer ability in the cohort, but also potentially raise the variance of the ability distribution, which Tincani (2017) and Booij, Leuven and Oosterbeek (2016) both show to have important effects on student achievement (conditional on average peer ability).

Table 6: Effect of exposure to elite families in high school on high school grades

	i) Not controlling for peer ability			**ii) Controlling for peer ability**		
	(1)	(2)	(3)	(4)	(5)	(6)
	Total	Low SES	High SES	Total	Low SES	High SES
A - Outcome: Overall GPA						
Proportion parent w/ elite degree	-0.118***	-0.171***	-0.046***	-0.030***	-0.054***	-0.006
	(0.013)	(0.016)	(0.012)	(0.010)	(0.013)	(0.012)
Average peer middle school GPA				-0.306***	-0.318***	-0.202***
				(0.014)	(0.015)	(0.030)
B - Outcome: Teacher-assessed internal grades						
Proportion parent w/ elite degree	-0.110***	-0.163***	-0.040***	-0.019*	-0.041***	0.004
	(0.013)	(0.016)	(0.012)	(0.010)	(0.013)	(0.012)
Average peer middle school GPA				-0.319***	-0.331***	-0.228***
				(0.013)	(0.014)	(0.028)
C - Outcome: Externally-assessed written exam grades						
Proportion parent w/ elite degree	0.025***	0.030***	0.030*	0.057***	0.062***	0.048***
	(0.009)	(0.012)	(0.016)	(0.010)	(0.013)	(0.016)
Average peer middle school GPA				-0.110***	-0.087***	-0.091***
				(0.012)	(0.014)	(0.031)
D - Outcome: Semi-externally assessed oral exam grades						
parent w/elite degree	-0.036***	-0.065***	-0.012	-0.004	-0.030**	0.003
	(0.008)	(0.011)	(0.014)	(0.009)	(0.012)	(0.015)
				-0.108***	-0.093***	-0.076**
				(0.012)	(0.015)	(0.037)
Number of observations	177,219	58,328	20,018	177,219	58,328	20,018
Number of schools	556	524	459	556	524	459

Hoxby and Weingarth (2006) also shows that marginal changes in the distribution at the top and bottom of the ability distribution can have different effects on student achievement - in our context a marginal increase in the proportion of elite peers in the student's cohort would most likely raise the upper tail of the distribution, which could be particularly influential if high-achievers have particularly strong effects on the rest of their peers (this would correspond to the 'Shining Light Model' in Hoxby and Weingarth (2006) typology of academic peer effects).

In order to better understand the effect of elite peers on student GPA therefore we re-estimate the model this time controlling for average peer ability, where ability is measured by student's middle school GPA. In doing so, we exclude student i's own middle school GPA as is conventional in the literature. That is, we estimate:

$$GPA_{isc} = \alpha_1 P_{-ics} + \alpha_2 T_{ics} + X'_{ics}\alpha_3 + \alpha_4 \overline{M_{-ics}} + \alpha_s + \rho_c + \epsilon_{ics} \tag{4}$$

where GPA_{isc} is student i's high school GPA and $\overline{M_{-ics}}$ measures the average of middle school GPAs among student i's high school cohort (excluding student i).

The estimates of coefficients α_1 and α_4 are shown in the last three columns of Table 6, Panel A. Average peer ability has a strong and negative effect on high school GPA, which is consistent with an ordinal rank effect. As expected from the fact that elite peers are high achievers, the elite peer effect on GPA decreases in absolute value when we control for average peer ability. Most strikingly, it becomes very small and statistically indistinguishable from zero high SES students but remains negative and statistically significant for low SES students.

There are a number of possible behavioural mechanisms that could underlie this negative effect, which we aim to better understand in the third part of our paper. But for now, these results provide an important clue for why elite peers have a lower effect on the probability of enrolling in an elite degree for low SES students than for high SES students. We now aim to quantify how important this result is for our benchmark results.

5.2 Mediation analysis

We have so far shown that: a) there is a strong, positive peer effect of elite families on the probability of enrolling in an elite degree and b) a strong, negative peer effect of elite families on GPA. This

implies that, conditional on GPA, exposure to elite families must encourage students to enroll in elite degrees (in order for the overall effect to be positive). In this subsection, we ask how large this direct effect is.

Consider the following model, which corresponds to our main model this time including GPA as a determinant of the decision to enroll in an elite degree:

$$Y_{isc} = \gamma_1 P_{-ics} + \gamma_2 GPA_{ics} + X'_{ics}\gamma_3 + \gamma_4 \bar{M}_{-ics}\alpha_s + \rho_c + \epsilon_{ics} \tag{5}$$

where the coefficient γ_1 is the direct peer effect of elite families conditional on GPA and γ_2 is the effect of GPA on the probability of enrolling in an elite degree. A naive estimation of equation (5) by OLS would not identify γ_1 in an unbiased way because, as shown earlier, GPA_{ics} is likely to be correlated with unobservable individual determinants of elite degree enrollment (and hence endogenous) and GPA_{ics} is correlated with P_{-ics}. In order to identify γ_1 and γ_2 in an unbiased way, we therefore need to instrument GPA_{ics} in equation (5). This exercise can be seen as a causal mediation analysis, where GPA is an endogenous mediator of the effect of P_{ics} on Y_{isc} and needs to be instrumented with a variable that affects Y_{isc} only through its effect on GPA_{ics} (Celli, 2021).

To do this, we exploit a unique feature of the Norwegian high school system, whereby students are randomly allocated to take externally assessed examinations in a specific subject in years 2 and 3 of high school. Specifically, we instrument GPA_{ics} with an indicator for whether the student was randomized into taking math as an externally assessed subject in the second or third years of high school. The instrument verifies the rank condition since, by nature, the randomisation should not be orthogonal any unobservable determinant of achievement (and we have school fixed effects in the regression to account for the fact that randomisation is done within schools).

The IV estimates are reported in Table 7. Panel A reports the first stage and confirms that the instrument is relevant, especially for the low SES sample where the F-stat is 28. The F-stat for the high SES sample is much lower, which is intuitive given that high SES students perform very highly anyway and there is therefore less margin for the instrument to affect their GPA. However, given that we do not find a negative peer effects on overall GPA (conditional on the average middle school GPA among the student's peers), the fact that the IV is not relevant for the high SES sample is not an issue since for this group the indirect effect is 0.

Panel B of Table 7 reports the IV estimates of equation (5) and show that the direct effect of elite peers on for low SES students is 0.040 and it is statistically significant. Given that overall GPA does not have an effect on the probability of enrolling in an elite degree for high SES (once we condition on average peer ability), this coefficient is to be compared with the OLS coefficient on elite degree from the benchmark specification controlling for average peer ability $\bar{M}_{-ics}$ (but not controlling for GPA_{ics}). The estimates of this specification are reported in column Panel C of Table 7, which is 0.063 (0.009).

To summarize the findings from this second part of this analysis, we have shown that (conditional on average peer ability), the overall effect of elite peers on elite degree enrollment is due to a direct effect of elite peers on the probability to apply to an elite degree (conditional on GPA) and an indirect effect of elite peers on GPA. Quite strikingly, elite peers penalizes the academic performance of low SES students while having no effect on that of high SES students. On the other hand, the direct effect of elite peers on students' willingness to apply to an elite degree is higher for high SES students than it is for low SES students. Specifically, this SES gap in the direct effect explains about half of the overall effect while the SES gap in the indirect effect explains about the other half. We now try to better understand the behavioral mechanisms underlying these SES differences in the direct and indirect effects of elite peers.

6 Behavioral mechanisms underlying the direct and indirect effect of elite peers

6.1 Direct effect of elite peers on elite degree enrollment

As mentioned in the introduction, one channel through which elite peers could affect students' elite degree enrollment conditional on GPA is by affecting their preferences and subjective beliefs over the probability that they would be accepted in such a degree. By interacting with the parents of their elite parents, students may acquire information about these educational routes and the types of jobs that they could be doing with those degrees. They could also acquire more accurate information about their chances to be accepted at those degrees, given their GPA. Students may also change their preferences over these degrees if they know that several of their high school friends will also be applying and likely enrolling. These potential effects on students' preferences and/or information could lead students to increase their likelihood of applying to elite degrees and/or to

Table 7: IV estimates of the direct effect of elite peers on elite degree enrollment

	Low SES	High SES
A - First Stage IV		
Outcome: Overall high school GPA (std)		
Proportion of parents with elite degree (std)	-0.0501***	-0.00518
	(0.00680)	(0.0102)
Student took written math exam (IV)	0.0375***	0.0277*
	(0.00680)	(0.0121)
Average peer ability		
F-statistic	*27.939*	*5.23*
B - Second Stage IV		
Outcome: Indicator for being enrolled in an elite degree		
Proportion of parents with elite degree (std)	0.040***	0.060**
	(0.006)	(0.022)
High school GPA (std)	0.467***	2.247*
	(0.092)	(0.940)
Average peer ability		
C - OLS benchmark conditioning on average peer ability		
Outcome: Indicator for being enrolled in an elite degree		
Proportion of parents with elite degree (std)	0.023***	0.060***
	(0.003)	(0.009)
Average peer ability	-0.028***	-0.105***
	(0.003)	(0.017)
Number of observations	58304	19968

pick better matches for them given their GPA, ultimately leading their to increase their probability to enroll given their GPA.

While separating out whether the direct elite peer effects operates preferences or beliefs is beyond the scope of this paper, in this section we aim to better understand why the direct effect of elite peers is lower for low SES students than it is for high SES students. We postulate two main hypotheses. The first hypothesis is that low SES students are less likely to interact with their elite peers and their families than high SES students. The literature on the social stratification of friendship networks is mixed, but does suggest that *a priori* this may be a possibility. While we neither have data on friendship networks nor on classroom composition to directly test this hypothesis, we tease this out

by comparing the elite peer effect in small vs. larger school. The idea is that, in small schools, friendship networks should be less socially stratified than in large schools, so we should find that the SES gap in the direct effect of elite peers is lower in smaller schools than in larger schools if this hypothesis is true. We therefore re-estimate our benchmark specification splitting the sample into schools with number of pupils below and above the median school size in the sample. The results of this specification are reported in Table 8, which show that indeed this could be a possibility.

Table 8: Effect of elite peers on the probability of enrolling in an elite degree, by school size

	(1) Full sample	(2) Low SES	(3) High SES
A - Small schools (school size below median)			
Proportion of parents with elite degree (std)	0.008**	0.006*	-0.001
	(0.004)	(0.003)	(0.013)
Number of pupils	89,005	32,699	7,474
Number of schools	457	425	360
B - Large schools (school size above median)			
Proportion of parents with elite degree (std)	0.031***	0.016***	0.049***
	(0.004)	(0.004)	(0.009)
Number of pupils	88,214	25,629	12,544
Number of schools	99	99	99

Notes: Data source, Norwegian administrative data. Sample of students ending middle school and entering high school between 2002-2012. OLS estimates of a regression of an indicator for whether the student is enrolled in an elite degree within 6 years of starting high school on: the proportion of parents with elite degree in the student's school's cohort, student's gender, middle school GPA, an indicator for whether the student was born in Norway, mother and father's highest education level, an indicator for whether the student's own parent have an elite education, and an indicator for whether the student's family income is in the top decile of the overall income distribution. All models also include cohort and school fixed effects. Column (1) reports the coefficient on the proportion of parents with an elite degree estimated in the full sample, column (2) and column (3) report the same coefficient estimated in the low SES and high SES samples, respectively. The low SES sample is defined as the group of students who have at least one parent with no more than the compulsory level of education, but no parent with an elite education. The high SES sample is defined as the group of students who have at least one parent with a post-secondary education, but no parent with a compulsory level of education. Standard errors clustered at the school level. *** p<0.01, ** p<0.05, * p<0.1

Our second hypothesis for the lower direct effect of elite peers on low SES students is related to the notion of aspiration window. Ray (2006) argues that individuals' goals, aspirations, and beliefs are socially determined by those around them: they have an aspirations window. Genicot and Ray (2017) develops a model of socially determined aspirations where how far an individual's current standard of living is from their aspirations gives an aspirations gap, which drives behaviours. If

an individual's aspirations are too far from their current experience, they will have little incentive to try to close the gap as they will remain far from their goal. This idea could apply to low SES students: if elite degrees seem too far from their current experience (shaped in part by their non elite educated parents), they may not even consider elite degrees to be attainable and will apply to them (even if their grades would allow them to get in).

In order to test this hypothesis, we return to our IV specification and interact the peer variable P_{-ics} with a measure of local upward mobility (we also control for this variable in the specification).[8] The idea is that low SES children may perceive an elite degree as more attainable if they are surrounded by other individuals from low socio-economic backgrounds like them who have risen the social ladder. Specifically, we measure local upward mobility as the fraction of adults from a non-professional background who live in student i's municipality and who work in STEM, law or medicine occupations.

The results of this exercise are presented in Table 9, which show an positive coefficient on the interaction between the peer variable and the measure of local upward mobility. This indicates that low SES students living in more mobile areas are more likely to be sensitive to the influence of their elite peers than low SES students living in less mobile areas when making their higher education decisions. To give a sense of magnitude of this effect, we compute that, if aspirations rose to 61% (from a mean of 52%) then the peer effect for low SES students would reach the level in Table 2 for elite students. These results are consistent with Ray (2006)'s idea of aspiration window and suggest that mentoring programs aimed to provide information about higher education routes may be more successful among disadvantaged students if they are delivered by adults from similarly disadvantaged backgrounds.

6.2 Mechanisms underlying the effect of elite peers on GPA

We now turn to exploring the behavioral mechanisms underlying the indirect effect of elite peers on the GPA, and especially the difference in such effect between low and high SES students. Recall from Equation 4 that an increase in the fraction of elite peers penalizes more the high school GPA of low SES students than it does penalize the GPA of high SES students. In fact, when controlling

[8] Accordingly, we re-run the first stage where we now control for this measure of local upward mobility and interact it with the elite peer effect. Results available upon request.

Table 9: Role of aspirations

	(1) Low SES	(2) High SES
Parents w/elite degree	-0.041**	-0.554
	(0.021)	(0.406)
Parent w/elite * upward mobility	0.165***	1.373
	(0.048)	(0.908)
Upward mobility	0.129***	0.895
	(0.038)	(0.616)
High school GPA	0.470***	2.696
	(0.127)	(1.701)
F statistic IV	16.09	2.28
Observations	51,512	17,559
R-squared	488	399

Notes: Data source, Norwegian administrative data. Sample of students ending middle school and entering high school between 2002-2012. Two stage least squares estimation, IV for high school GPA is lottery to take written exam in maths. Dependent variable is indicator for studying for an elite (graduate) degree. Model controls for student Norwegian born, gender, middle school GPA, mother and father education and income in year before high school entry and fixed effects for school and year and peer mean middle school GPA. Standard errors clustered at school level. Upward mobility the % of workers in STEM, law or medicine occupations from a non-professional background.

for average peer ability in the cohort, the fraction of elite peers in the cohort only has a negative effect on the GPA of low SES students.

There are a number of channels proposed in the literature that could be at the root of this negative effect, including student effort, peer-to-peer learning, teacher effectiveness, and teacher bias. To shed light on the underlying mechanism(s), we exploit a unique feature of the way high school GPA is computed in Norway: overall GPA is a weighted average of three types of tests: teacher-assessed internal grades, external written exams and oral exams. A crucial difference between external written and external oral exams is that written exams are assessed blindly and by an examiner outside the school, while oral exams are assessed by both an external examiner and the student's teacher.

We use data on each of these three components of high school GPA and estimate equation (4) with each of these three types of scores as outcomes. The estimates of these regressions are shown in Panels B, C and D of Table 6 and we focus on the results shown in columns (4) through (6)

which corresponds to the specification controlling for average peer ability. On average, exposure to elite peers in high school *increases* grades on externally-assessed written exams for both high and low SES. In great contrast, exposure to elite peers *lowers* the grades of low SES students on exams assessed by teachers either fully (internal grades) or partly (oral exams). Elite peers have no effect on the internal grades and oral exam grades of high SES students, which indicates that the negative effect of elite peers on overall GPA is driven by the negative effect of elite peers on teacher assessed grades.

To the extent that these three types of exams test the same set of skills but only represent a different mapping between student's skills and grades, the results suggest that elite peers have an effect on teachers' grading behavior. Specifically, the higher the fraction of elite peers in the cohort, the stronger teachers become biased against low SES students. This result could corroborate anecdotal evidence that high SES parents may be more effective at applying pressure on teachers to give good grades to their children in order to enhance their higher education prospects.

Under the assumption that the three types of exams test the same skills, the findings do help us rule out a number of alternative other mechanisms underlying the negative effect of elite peers on teacher assessed grades. First, it is unlikely that there is a negative effect of elite peers on the effort of low SES students. If this were the case, we would most likely find a negative effect of elite peers on externally assessed written exams as well. Second, it is also unlikely that the negative effect captures an effect of on teacher effectiveness. Booij, Leuven and Oosterbeek (2016) for example finds a negative effect of the variance of peer ability on achievement among university students and interpret this finding as evidence that teachers are more effective in more homogeneous groups. If these were the case here, we would again most likely find a negative effect of elite peers on externally assessed written exams.

The conclusion that the negative effect of elite peers is driven by a bias in teacher's grading behavior hinges on the fact that we appropriately control for the 'rank effect'. Indeed, if externally-assessed written exams are not curved, while the other two types of exams are curved then the negative effect of elite peers on internal grades and oral exam grades could reflect ordinal rank effects of high-achieving elite peers on the grades of all other students. While controlling for average peer ability should control for such rank effect, one could argue that this variable doesn't appropriately control for rank effects if internal exams and oral exams test other do not test the exact same set

of skills as written exams do. For example, internal and oral exams may test students on their non-cognitive skills (e.g. communication skills and confidence), while external exams will only test students on their cognitive skills. If average peer ability does not appropriately control for rank effects on these non-cognitive skills, it could be captured by the negative effect of elite peers on internal and oral exam grades.

While we do not have direct measures of non-cognitive skills, such as communication or confidence, in Table A.2 column 1 and 2 we control for peer mean middle school differently - rather than the total GPA as in our benchmark we control for each MS GPA component including the teacher assessment, written externally assessed exam and the oral. The idea is that these separate test scores will better capture the student's rank in each of the skills that determine high school teacher and oral exam grades. If the teacher assessment in high school is driven by noncognitive skills then we assume the same to be true for the middle school assessment. However, as shown in Table A.2, controlling for these elements do not change the results, which indicates that it is unlikely that the peer effect of elite families confound a rank effect on unobservable skills.

Is the teacher bias linked to teacher traits? Our strategy already eliminates all time invariant teacher traits, but we examine the extent to which the peer effect of elite families varies when we control for time-varying teacher characteristics. The Norwegian data does not allow us to match individual teachers to individual pupils, so we construct school-cohort level variable describing teachers in the school in each academic year. Specifically, we re-estimate the main model (controlling for the student's rank) controlling additionally for the following school/cohort-level teacher characteristics: the proportion of teachers whose father was not a professional; the proportion of teachers whose father earned in the bottom half of the income distribution and the proportion of female teachers. The results of this exercise are reported in Table A.2 and show that the inclusion of these variables do not change the socio-economic gradient in the teacher assessed high school grades from Table 6. This is consistent with the fact that the peer effect of elite families on GPA reflects an adjustment of teacher grading behaviour to the proportion of elite families in the school increases.

7 Does exposure to elite families reduce intergenerational income mobility?

We conclude our analysis by considering the implications of our results for earnings inequalities and intergenerational earning mobility. If the return to enrolling in an elite degree is positive for both low and high SES, a direct implication of our results is that exposure to elite families reduces intergenerational income mobility. To investigate this hypothesis, we use data on the earnings of the five oldest cohorts in our data (entering high school between 2002 and 2007). By 2018, the last year of data that we use, these individuals are between 27 and 32 years old, which has been shown to be the age at which earnings rank becomes relatively stable and predictive of earnings rank at older ages.

Using these data, we first investigate the returns to an elite degree for the whole sample and our two subsamples. To do so, we regress our measure of earnings on an indicator for whether the student is enrolled in an elite degree, the set of individual level controls we included in equation (1), school and cohort fixed effects. The results of this specification are reported in Table 10. In line with Bütikofer, Risa and Salvanes (2021), we find evidence of very high average returns to enrolling in an elite degree: enrolling in an elite degree increases log earnings at 28-32 by 18%.

The results in the next two columns report the returns to an elite degree separately for our low and high SES group. Strikingly, the return is essentially the same for low and high SES students. This is an interesting finding - which we do not believe had been uncovered before - especially as it appears in great contrast with evidence from other countries. For example, Zimmerman (2019) finds no returns to elite degree for low SES students in Chile. Britton, Dearden and Waltmann (2021) finds that the returns to Russell Group universities, which are considered elite universities in England, is also lower for low SES students than it is for high SES students.

Given equally high earnings returns to an elite degree for low and high SES students and our benchmark results on elite peer effects from Table 2, we move on to estimate the elite peer effects on earnings. To do so, we re-estimate our benchmark equation (1), this time with earnings as outcome. We present the estimates of this specification in columns (4) through (6) of Table 10. Being exposed to elite peers in high school has a positive effect on earnings, but this effect is lower for low SES students than it is for high SES students. These results is in line with the earlier results that elite peers have a less positive effect for low SES students than for high SES students, although they

do not necessarily imply that the only way through which elite peers affect earnings is by boosting students' probability of enrolling in an elite degree. Indeed, elite peers may have other effects on earnings over and beyond their effect on educational attainment (for example through connections that could help secure a good job). Indeed, when re-estimating the model this time also controlling for whether the student has enrolled in an elite education, we still find a positive of elite degrees on earnings. Understanding these mechanisms is beyond the scope of the paper but we note that these findings as an interesting avenue for future research.

Together, these findings show that elite peers increase the educational attainment and earnings of low SES students, but because they have an even stronger effects on the outcomes of high SES students, exposure to elite peers exacerbates the intergenerational persistence in education. To get a sense of how large the effect of such social interactions are on intergenerational income mobility, we measure the extent to which exposure to elite peers exacerbates the intergenerational association in earnings. To do this, we estimate a regression of whether student i has earnings in the top decile of the income distribution (between 28 and 32) on an indicator for whether student i's parents' earnings were in the top decile of the income distribution when student i was between 15 and 19 years old and interact this variable with our peer variable P_{-ics}. The estimates of this regression are reported in and show a positive and significant coefficient on the interaction, confirming that this aspect of social interactions exacerbate intergenerational income mobility. A one standard deviation increase in the fraction of elite educated parents in high school increases the link between parent and child earnings by about 8% (0.007/0.085).

8 Conclusion

Socio-economic inequalities in elite education are high, even in countries like Scandinavian countries, where income inequality is notoriously low. This paper examines the role of social interactions in driving such inequalities both within and across generations in Norway. We show that exposure to elite peers in high school increases the enrollment in elite degree of students in a way that exacerbates socio-economic inequalities in elite education. This is due to the fact that elite peers have a much stronger positive effect on the probability of enrolling in an elite degree of high SES students than it does on that of low SES students.

We further show that this difference in the effect of elite peers between low and high SES students is due to two main factors. First, exposure to elite peers penalizes the GPA of low SES students, while it does not affect the GPA of high SES students. We exploit a unique feature of the Norwegian examination system to rule out competing explanations and argue that this pattern is most likely driven by teacher grading behavior adjusting to the presence of elite peers and to the detriment of low SES students.

Second, conditional on GPA students' exposure to elite peers increases their likelihood to apply to an elite degree, but this effect is higher for high SES students than it is for low SES students. We show that this difference is most likely between an aspiration gap between high and low SES students: low SES students may not necessarily think that achieving an elite degree is within the set of attainable objectives, given the fact that so few individuals in their immediate surroundings have low education.

Overall, our findings suggest that considering peer interactions is very important for policy-makers interested in improving the life chances of low SES students as well as intergenerational mobility. Specifically, we show that policies that increase social mixing in high school may well increase the fraction of first generation elites, but could also have the perverse effect of exacerbating the intergenerational persistence in elite education. Policy-makers must therefore be very careful in considering the heterogeneity in peer effects when designing policies aimed to reduce educational inequalities in school by affecting the allocation of students across schools. As we show in this paper, the very high and homogeneous monetary returns to an elite degree means that the strong intergenerational persistence in elite education is an important driver of the intergenerational transmission of income at the top end of the income distribution. Our paper sheds light on the important role that social interactions during high school play in driving this intergenerational link and the complex mechanisms underlying it.

Table 10: The effect of elite peers on earnings

	(1) Total	(2) Low SES	(3) High SES	(4) Total	(5) Low SES	(6) High SES	(7) Total	(8) Low SES	(9) High SES
Student ever enrolled in elite degree	0.182***	0.177***	0.161***				0.181***	0.176***	0.159***
	(0.004)	(0.008)	(0.010)				(0.004)	(0.008)	(0.010)
Proportion of parents with elite degree				0.022***	0.012***	0.039***	0.016***	0.009**	0.029***
				(0.003)	(0.005)	(0.010)	(0.003)	(0.004)	(0.009)
Number of observations	78,980	27,077	8,971	78,980	27,077	8,971	78,980	27,077	8,971
Number of schools	492	471	387	492	471	387	492	471	387

Table 11: Effect of elite peers on intergenerational income mobility

VARIABLES	(1) No controls	(2) Benchmark controls
Parent w/elite degree	0.039***	0.021***
	(0.003)	(0.003)
Parent in top decile (15-19)	0.085***	0.041***
	(0.005)	(0.005)
Parent top decile * parent w/elite degree	0.007*	0.011***
	(0.004)	(0.004)
Constant	0.141***	0.185***
	(0.003)	(0.006)
Number of observations	55,234	55,234
Number of schools	480	480

References

Andersen, Martin, and Sturla Lokken. 2020. "The final straw: high school dropout for marginal students." Statistics Norway Discussion Paper No. 894.

Angrist, Joshua, and Kevin Lang. 2004. "Does School Integration Generate Peer Effects? Evidence from Boston's Metco Program." *American Economic Review*, 94(5): 1613–1634.

Black, Sandra E., Paul J. Devereux, and Kjell G. Salvanes. 2013. "Under Pressure? The Effect of Peers on Outcomes of Young Adults." *Journal of Labor Economics*, 31(1): 119–153.

Black, Sandra, Paul Devereux, and Kjell Salvanes. 2005. "Why the apple doesn't fall far: Understanding the intergenerational transmission of education." *American Economic Review*, 95(1).

Boneva, Teodora, Marta Golin, and Christopher Rauh. 2021. "Can Perceived Returns Explain Enrollment Gaps in Postgraduate Education?" *Labour Economics*.

Booij, Adam S, Edwin Leuven, and Hessel Oosterbeek. 2016. "Ability Peer Effects in University: Evidence from a Randomized Experiment." *The Review of Economic Studies*, 84(2): 547–578.

Britton, Jack, Elaine Drayton, and Laura van der Erve. 2021. "Which university degrees are best for intergenerational mobility?" IFS report.

Britton, Jack, Lorraine Dearden, and Ben Waltmann. 2021. "The returns to undergraduate degrees by socio-economic group and ethnicity." IFS report 978-1-83870-244-1.

Bütikofer, Aline, Erling Risa, and Kjell G Salvanes. 2021. "Status traps and human capital investment." *Unpublished*.

Bütikofer, Aline, Rita Ginja, Fanny Landaud, and Katrine Lokken. 2020. "School selectivity, peers and mental health." *Unpublished*.

Carneiro, Pedro, and James Heckman. 2002. "The Evidence on Credit Constraints in Post-Secondary Schooling." *The Economic Journal*, 112(482): 705–734.

Caucutt, Elizabeth M., Lance Lochner, and Youngmin Park. 2017. "Correlation, Consumption, Confusion, or Constraints: Why Do Poor Children Perform so Poorly?" *The Scandinavian Journal of Economics*, 119(1): 102–147.

Celli, Viviana. 2021. "Causal mediation analysis in economics: Objectives, assumptions, models." *Journal of Economic Surveys*, 36(1): 214–234.

Chetty, Raj, John N Friedman, Emmanuel Saez, Nicholas Turner, and Danny Yagan. 2020. "Income Segregation and Intergenerational Mobility Across Colleges in the United States*." *The Quarterly Journal of Economics*, 135(3): 1567–1633.

Cools, Angela, Raquel Fernández, and Eleonora Patacchini. 2019. "Girls, boys, and high achievers." National Bureau of Economic Research.

de Gendre, Alexandra, and Nicolas Salamanca. 2020. "On the mechanisms of ability peer effects." IZA Working Paper No. 13938.

Feld, Jan, and Ulf Zoelitz. 2017. "Understanding peer effects - on the nature, estimation and channels of peer effects." *Journal of Labor Economics*, 35(2): 34–68.

Genicot, G, and D. Ray. 2017. "Aspirations and Inequality." *Econometrica*, 85(2): 489–519.

Has, S, J Anders, J Jerrim, and N Shure. 2021. "Educational expectations of UK teenagers and the role of socio-economic status and economic preferences." CEPEO Working Paper No. 21-11.

Hastings, Justine S., Christopher A. Neilson, Anely Ramirez, and Seth D. Zimmerman. 2016. "(Un)informed college and major choice: Evidence from linked survey and administrative data." *Economics of Education Review*, 51: 136–151. Access to Higher Education.

Heckman, James, and Rasmus Landersø. 2021. "Lessons for Americans from Denmark about inequality and social mobility." *Labour Economics*, 101999.

Hoxby, Caroline. 2000. "Peer effects in the classroom: Learning from gender and race variation." National Bureau of Economic Research.

Hoxby, Caroline, and Gretchen Weingarth. 2006. "Taking race out of the equation: school reassignment and the structure of peer effects." Working Paper.

Landerso, Rasmus, and James Heckman. 2017. "The Scandinavian Fantasy: The Sources of Intergenerational Mobility in Denmark and the US." *The Scandinavian Journal of Economics*, 119(1): 178–230.

Lavy, Victor, M. Daniele Paserman, and Analia Schlosser. 2011. "Inside the Black Box of Ability Peer Effects: Evidence from Variation in the Proportion of Low Achievers In the Classroom." *The Economic Journal*, 122(559): 208–237.

Lochner, Lance, and Alexander Monge-Naranjo. 2012. "Credit Constraints in Education." *Annual Review of Economics*, 4(1): 225–256.

Pekkarinen, Tuamas, Kjell Salvanes, and Matti Sarvimaki. 2017. "The Evolution of Social Mobility: Norway during the Twentieth Century." *The Scandinavian Journal of Economics*, 119(1): 5–33.

Ray, D. 2006. "Aspirations, Poverty and Economic Change." In *Understanding Poverty.* , ed. Benabou R. Banerjee, A.V. and D. Mookherjee. Oxford:Oxford University Press.

Tincani, Michela. 2017. "Heterogeneous Peer Effects in the Classroom." *HCEO Working Paper 2017-006.*

Zimmerman, Seth D. 2019. "Elite colleges and upward mobility to top jobs and top incomes." *American Economic Review*, 109(1): 1–47.

A Additional figures and tables

Table A.1: Effect of exposure to elite families in high school on the probability of enrolling in an elite degree : Coefficients on control variables

	(1) All	(2) Low SES	(3) High SES
Proportion of parents with elite degree (std)	0.026***	0.013***	0.040***
	(0.003)	(0.003)	(0.008)
Student is a female	-0.073***	-0.053***	-0.125***
	(0.003)	(0.003)	(0.007)
Student is born in Norway	-0.011***	-0.032***	0.013
	(0.003)	(0.004)	(0.009)
Student's middle school GPA (std)	0.132***	0.086***	0.255***
	(0.004)	(0.003)	(0.007)
Proportion of student's own parent with an elite degree	0.182***		0.162***
	(0.007)		(0.021)
Student's parents are in top income decile	0.027***	0.004	0.042***
	(0.003)	(0.005)	(0.009)
Mother's highest education level (ref = compulsory level)			
High school	0.015***	0.007	0.032***
	(0.003)	(0.005)	(0.011)
University	0.006**		0.006
	(0.002)		(0.010)
Father's highest education level (ref = compulsory level)			
High school	0.018***	0.018***	0.008
	(0.002)	(0.004)	(0.018)
University	0.020***		0.022**
	(0.002)		(0.011)
Number of students	177,219	58,328	20,018
Number of schools	556	524	459

Table A.2: Sensitivity: effect of elite parent peers on high school grades

	(1) Low SES Control peer mean	(2) Elite SES MS GPA components	(3) Control for	(4) teacher traits
A - Overall GPA				
parents w/elite degree	-0.054***	-0.021*	-0.058***	-0.016
	(0.014)	(0.012)	(0.017)	(0.014)
B - Teacher assessment				
parents w/elite degree	-0.039***	-0.007	-0.047***	-0.004
	(0.013)	(0.012)	(0.016)	(0.014)
C - External written exams				
parents w/elite degree	0.058***	0.028*	0.056***	0.021
	(0.013)	(0.017)	(0.016)	(0.018)
D - External oral exams				
parents w/elite degree	-0.038***	0.003	-0.049***	-0.013
	(0.014)	(0.017)	(0.017)	(0.020)
Observations	58,610	20,018	33,595	11,333
Number of skole_orgnr1	524	459	387	336

Notes: Data source, Norwegian administrative data. Sample of students ending middle school and entering high school between 2002-2012. Dependent variable is high school GPA score. Controls from benchmark model. Columns 1 and 2 controls for MS gpa components (written exam, teacher assessment, oral exam). Columns 3 and 4 control for the proportion of teachers in the school from a non professional background, from a low income background (whose parents were in the bottom half of the income distribution) and the proportion female. Standard errors clustered at school level. Low (elite) education household contains at least one parent with compulsory (elite) education.