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IZA DP No. 15560

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**Sarah Cattan**
*Institute for Fiscal Studies and IZA*

**Kjell G. Salvanes**
*Norwegian School of Economics, CEPR, CESifo, HCEO and IZA*

**Emma Tominey**
*University of York, HCEO and IZA*

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ISSN: 2365-9793

**IZA – Institute of Labor Economics**

Schaumburg-Lippe-Straße 5–9
53113 Bonn, Germany

Phone: +49-228-3894-0
Email: publications@iza.org

www.iza.org

# ABSTRACT

## First Generation Elite: The Role of School Networks*

Intergenerational persistence in studying for elite education is high across the world. We study the role that exposure to high school peers from elite educated families ('elite peers') plays in driving such a phenomenon in Norway. Using register data on ten cohorts of high school students and exploiting within school, between cohort variation, we identify the causal impact of elite peers on the probability of enrolling in elite education for students from different socioeconomic (SES) backgrounds. We show that exposure to elite peers in high school does drive enrolment into elite degree programmes, but the effect for low SES students is a third of the size than for high SES students. We explore mechanisms behind this pattern – finding that elite peers have a complex effect on students' GPA which is a key part of the story. Elite peers increase the effort of both low and high SES students, but they also push the rank of other students down and trigger a change in teacher behaviour which disadvantages low SES students. To quantify the contribution of this mechanism, we perform a causal mediation analysis exploiting a lottery in the assessment system in Norway to instrument GPA. We find that the indirect effect of elite peers on enrolment through GPA explains just less than half of the total peer effect. Our concluding analysis shows that elite peers in high school raises intergenerational mobility for poor students, but increases persistence for rich students, thereby simultaneously facilitating first generation elite whilst contributing to the high intergenerational persistence at the top of the education and income distribution.

**JEL Classification:** I24, J24, J62

**Keywords:** peers, elite university, subject choice, social mobility, teacher bias

**Corresponding author:**
Emma Tominey
Department of Economics and Related Studies
University of York
Heslington, York YO10 5DD
United Kingdom
E-mail: emma.tominey@york.ac.uk

* We have received useful comments from many including Gordon Dahl, Julie Cullen, Anthony Lepinteur, Michela Tincani, Jan Stuhler, and seminar audience at the University of Oxford, University of Turin, University of California San Diego, CEPEO Institute of Education UCL, University of Copenhagen, University of Sheffield participants at the NORFACE IFS workshop, York Workshop for Labour and Family Economics, London School of Economics and Sapienza workshop on Opportunity and Mobility, Erasmus University Rotterdam, Swedish Institute for Social Research, University of Bergen workshop on Health, Human Capital and Social Insurance, University of Essex, Royal Holloway University of London. All remaining errors are our own. The authors gratefully knowledge financial support from the ESRC-funded Centre for the Microeconomic Analysis of Public Policy (ES/T014334/1), the Rockwool Foundation, and the European Research Council for grants agreement no. 819752 - DEVORHBIOSHIP - ERC-2018COG and ERC-2014-CoG-646917-ROMIA.

## 1 Introduction

Socioeconomic segregation in higher education is pervasive across the world. Students from rich backgrounds are more likely to attend university than their poorer counterparts, and if they do, they are also more likely to attend highly selective or 'elite' institutions. Intergenerational persistence in elite education is a phenomenon that characterizes countries with both high and low income inequality (Britton, Drayton and van der Erve, 2021; Heckman and Landersø, 2021; Landerso and Heckman, 2017). In the US for example, 70% of Ivy League undergraduates have parents in the top quintile of the income distribution while only 3% of them have parents in the bottom quintile (Chetty et al., 2020*a*). In Norway, 47% of elite graduates come from the lowest family income quintile while only 7% come from the bottom one.[1]

Identifying the barriers that prevent students from becoming first generation elite is particularly important to understand the roots of income inequality because elite degrees have high labour market returns (Anelli, 2020; Britton, Dearden and Waltmann, 2021; Zimmerman, 2019). This paper focuses on one potential barrier: the role that access (or lack of) to social networks during high school plays in determining elite degree enrolment and inequalities therein. We ask how and why exposure to high school peers from elite educated families (elite peers henceforth) shapes students' decisions to enrol in an elite degree and what implications this has for intergenerational persistence in education and income.

Access to elite educated social networks at school has the potential to be highly influential when taking important decisions such as college and major choice through two broad channels. First, elite peers could affect high school GPA, a central determinant of university degree choice. These effects could be either positive, through spillovers on effort and learning, or negative, through pressure on student's rank and/or confidence. Further, if teachers are prone to implicit bias, a higher proportion of elite peers may also trigger some distortion in the way that teachers assess elite students relative to non-elite students of similar ability. Second, elite peers and their families could affect university application behaviour conditional on GPA, e.g. by raising aspirations and providing information on access and returns to these routes (Lundberg 2020; Porter and Serra 2020; Mani and Riley 2019;

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

Michelman, Price and Zimmerman 2022).

While the sign of the overall effect of elite peers on elite degree enrolment is *a priori* ambiguous, there are several reasons to expect it would be heterogeneous across students from different socioeconomic backgrounds. Peer effects are heterogeneous across the ability distribution (as shown by Feld and Zoelitz (2017); Lavy, Paserman and Schlosser (2011); Tincani (2017) among others). Also the extent to which elite peers have the potential to shape outcomes could vary across students based on their prior beliefs of what outcomes are desirable and attainable (Ray, 2006). To the extent that these beliefs are socially determined, the effect of elite peers could be heterogeneous across students from different socioeconomic backgrounds.

The objective of this paper is to present novel evidence on the causal link between elite peers and enrolment in elite degree programmes, its socioeconomic gradient, and its underlying mechanisms. We do so for the context of Norway, where elite degrees are a widely recognised set of highly selective degrees leading to top positions and a centralised admission system allocates students to degrees based on their high school GPA and degree ranking.[2] Our analysis exploits register data linking the education and labour market records of high school students to those of their parents, their peers and their peers' parents for cohorts graduating from middle school and enrolling in high school's academic track between 2002 and 2012. Among these cohorts, 10% of students eventually enrol in an elite degree. By age 30-32, they are already 3.5 times more likely to earn in the top 1% of the income distribution than their non-elite educated counterparts, with many of them on their way to become future leaders in the private and public sectors (Bütikofer, Risa and Salvanes, 2021; Kirkebøen, 2010).

The first contribution of the paper is to show that, while elite peers encourage the average student to enrol in an elite degree, this effect 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). To identify this effect, we exploit within school, between cohort variation in peer composition. This approach has been extensively used since it was initially proposed by Hoxby (2000),[3] and we

[2]The definition of elite degrees includes 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 8.

[3]Among others, see Angrist and Lang (2004); Black, Devereux and Salvanes (2013); Cools, Fernández and Pat-

perform a wide set of robustness checks to probe its validity in our context. Our estimates imply that elite peers play a meaningful role in driving the gap in elite degree enrolment between the low SES and the high SES groups: around 7% of the gap in elite degree enrolment can be attributed to the facts that low SES students are less exposed to elite peers on average and 5% to the fact that they benefit from elite peers less than their high SES counterparts.

The second contribution of the paper is to estimate the effect of elite peers on high school GPA. Using within school, between cohort variation, we first establish that elite peers have a negative effect on high school GPA, and particularly so for low SES students. To understand why, we exploit a unique feature of the Norwegian high school system, whereby high school GPA is a weighted sum of grades obtained on exams assessed by a blind examiner and exams assessed by the student's teacher. We show that, while elite peers improve all students' scores on blind exams - suggesting an increase in effort or motivation of students - elite peers have a particularly negative effect on the teacher assessments of low SES students. The downgrade in teacher assessments from exposure to elite peers is partially explained by elite peers lowering the rank of other students. This is not the whole story, as even within student cohort rank the teacher downgrade is larger for the low SES students, pointing to an implicit teacher bias against low SES students which varies with the class composition.

The third contribution of the paper is to quantify the contribution of the effect of elite peers on GPA to the overall effect of elite peers on elite degree enrolment in a causal mediation analysis. We account for the endogeneity of GPA with respect to individual elite degree enrolment by exploiting a lottery inherent in the Norwegian examination system that creates exogenous variation in GPA.[4] Specifically, schools randomise the subjects on which students are blind externally-assessed in their second and third year. We show that student assignment to externally-assessed maths exams is both balanced on a number of students' observable characteristics and a strong determinant of GPA, making it a plausibly valid and relevant instrument for GPA. Our IV estimates imply that the negative effect of elite peers on GPA is around 70% as large as the positive effect of elite peers students' application behaviour conditional on GPA. This positive effect could capture channels including aspirations, information or role models.

acchini (2019); Lavy, Paserman and Schlosser (2011).

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

Our final contribution is to link the exposure to elite educated peers as a mechanism for intergenerational *income* mobility. To do so, we use data on the earnings of students born between 1986 and 1988 who have acquired several years of post-graduate labour market experiences by 2018, our last year of data. We first show that the returns to an elite degree estimated in a Mincer regression are high and only slightly lower for low SES students than for high SES students. We then estimate a flexible intergenerational rank-rank correlation regression of parents' percentile rank on their child's rank age 30-32 and allow the coefficients to vary with the degree of exposure to elite degrees. [5] The analysis reveals that exposure to elite peers in high school exacerbates intergenerational income persistence at the top of the distribution of parent income, but raises mobility at the bottom. This suggests that social interactions are a potential tool to become a first generation elite but also 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 in Norway (Pekkarinen, Salvanes and Sarvimaki, 2017).

Our paper speaks to three strands of literature. First, it contributes to the intergenerational mobility literature, which has evidenced strong intergenerational persistence in education and income in a variety of contexts. Our paper adds to this literature by providing causal evidence that differential access to - and the effect of - elite peers, is an important driver of the high persistence in education in Norway, especially at the top of the education distribution. The lack of university tuition fees and of legacy status in Norway makes it an opportune context to study the role of social networks in driving inequality, since other mechanisms, such as credit constraints and legacy admission mechanisms, are not likely to be salient (Chetty et al., 2020*a*; Lochner and Monge-Naranjo, 2012). But the results are likely to be relevant for other Scandinavian and non-Scandinavian contexts, which also have high levels of socioeconomic segregation in high schools and high levels of intergenerational persistence in education.

Second the paper relates to the large literature on the effect of peer characteristics on educational and economic outcomes. Our results add to a growing body of evidence about the heterogeneity

[5] Due non-classical measurement error in earnings both for fathers and for sons estimates of intergenerational mobility may be downward biased depending on which age is a good predictor for life-time earnings. Bhuller, Mogstad and Salvanes (2017) finds that earnings measured in the early 30s are a good predictor of life time earnings for Norway using data across the whole life-cycle. Nybom and Stuhler (2017) finds that using income ranks in contrast to log earnings is less dependent on the exact age of measuring earnings. We use the rank of means earnings for ages around 30 for the students.

of peers effects. It is most closely linked to Bertoni, Brunello and Cappellari (2020) and Cools, Fernández and Patacchini (2019) who also focus on the effects of peers with high parental education and their heterogeneity (by socioeconomic background and by gender, respectively). Our paper exploits unique features of the institutional context to provide a rich description of the mechanisms underlying the effect of elite peers on elite degree enrolment and to quantify the relative contribution of these mechanisms.

Finally, our analysis of elite peer effects on blind and non-blind assessments speaks to the literature on teacher biases in subjective assessments. Several papers in the literature contrast these two types of assessments to provide evidence of teacher stereotypes (Burgess and Greaves, 2013; Lavy, 2008), while other papers directly elicit teacher bias using Implicit Bias tests (Alesina et al., 2018; Carlana, 2019). We add to this literature documenting the presence of teacher stereotype by showing evidence consistent with the fact that teacher biases against low SES students can be exacerbated by the peer composition of the cohort, with long-term implications for the education and labour market outcomes of low SES students.

## 2 The Norwegian Education System

**High school** Norwegian education has been compulsory until the age of 15-16 since 1959; all students must now complete seven years of primary school followed by three years of middle school (Black, Devereux and Salvanes, 2005*b*).[6] After completing these 10 years of education, students decide whether to continue their education in high school or to drop out to join the labour 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.

The assignment mechanisms of students to high schools varies across counties and cohorts. In some counties (including all rural counties), schools have catchment areas and geographical distance determines student high school allocation.[7] Other counties have a free high school choice system where intake is centralised and based on middle school GPA. During our period of analysis, which focuses on cohorts graduating from middle school between 2002 and 2012, eight out of nineteen

[6] The seven years of primary school includes a year of preschool education, which was made mandatory in 1996.

[7] A small number of private colleges instead require tuition fees for students - only one in our sample.

counties had free school choice. Because these areas tend to be the most densely populated areas, the majority of high school students in our sample had free school choice.[8]

**Higher education** Higher education institutions include universities (in Bergen, Oslo, Trondheim and Tromsø) and university colleges. Since the early 2000s, Norwegian universities offer three-year bachelor degrees 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. There are 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 (NSELF).[9]

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). Since the late 1990s, admission to public higher education institutions has been centralised and is based on student ranking for programmes and high school GPA, conditional on students having completed the requisite high school modules (e.g. maths at high school is required for a maths degree). Every year, the deadline for applying to programmes is mid-April, and it is then that students first submit their ranking of up to fifteen programmes to a central organisation - the Norwegian Universities and Colleges Admission Service.[10] Students can adjust their ranking until July, and it is then that offers are made sequentially where the order is determined by the students' application score derived from the student's high school GPA.

**Elite degrees** Whereas 'elite' higher education refers to highly competitive, private institutions with high tuition fees such as Ivy League colleges in the US (e.g., Chetty et al. 2020*a*) and 'Russell Group' universities in the UK (Britton, Drayton and van der Erve, 2021), in Norway 'elite education' is described as completing specific degrees at specific institutions that yield the best earnings

[8]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; Dalla-Zuanna, Liu and Salvanes, 2020). Oslo moved from a local catchment to school choice admissions based system between 2006-2009 but reverted back from 2010; whilst Bergen moved to school choice admissions from 2006 onward.

[9]The NSELF is a national body founded in 1947 with the task to provide student aid in the form of direct transfers or scholarships and to issue loans under conditions specified by the Norwegian state. Since the 1980s financial aid is not dependent on the student's own means or that of their parents.

[10]The Norwegian Universities and Colleges Admission Service handles the admission process to all universities and to most university colleges, and therefore to all elite degrees we consider in this paper.

outcomes. Specifically, elite degrees are five-year masters degrees in a select set of subjects at specific universities, and we follow Bütikofer, Jensen and Salvanes (2018) in defining elite programs as degrees at the master level (or above) in Economics from the Norwegian School of Economics, Engineering at the Norwegian University of Science and Technology, Engineering School in Trondheim or Norwegian University of Science and Technology and in Economics, Law or Medicine from the University of Oslo, Bergen, Trondheim and Tromsø. Not only are these elite programmes associated with high earnings, but a majority of future leaders in the private and public sectors are recruited from these institutions (Bütikofer, Risa and Salvanes, 2021; Kirkebøen, 2010). Figure 1 plots the earnings percentile distribution across education groups and confirms that the elite educated are positioned high in the income distribution.

Similarly to the US or the UK, access to elite degrees is highly competitive. Important differences, however, are that there are no tuition fees for these degrees and no easier access for legacy students - because a centralised admission system allocates students based only on high school GPA (given the student's ranking of programmes). As we show in the next section however, despite these equalising 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 social networks in high schools play in driving these inequalities.

**High school GPA** High school GPA is a combination of teacher-assessed internal grades and external oral and written exam grades. In each of the three years of high school, students receive a teacher assessment on all subjects. In addition, they must take several mandatory exams in May or June of each academic year. In their first year, 20 percent of students are chosen randomly to sit for a final exam in one course. In their second year, all students sit a final exam in one course, either oral or written and the subject of these exams is chosen at random. In their third year, all students take four exams: one written exam in Norwegian language, two written exams in two other subjects and a final oral exam in one other subject (Andersen and Lokken, 2020). It is the responsibility of each school to decide which topic each student at each school will be examined on, with the exception of mandatory exams (Norwegian in the third year). Importantly, written exams are set and marked centrally while oral exams are undertaken and marked by a combination of an external examiner and the student's teacher. As described in detail in Andersen and Lokken (2020), the process of assigning a subject to be examined via a written or oral exam varies across schools and across cohorts (and of course across the set of subjects a student chooses to study). There are several administrative procedures in place to avoid any selection of students for particular courses or type of exams, and in fact there are no incentives to do so. Andersen and Lokken (2020) find strong support for the assignment of exams to specific subjects and students to be random and independent of gender, past performance or social background. We make use of this lottery later in the paper (section 7) and, like Andersen and Lokken (2020), find strong support for the random assignment of exam subject within school and programme of study in our sample.

## 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 the academic track of high school between 2002 and 2012.[11] The linked data allows us to follow these students from middle school through to high school, onto university (if they ever enrol) and into the labour market.[12] In section 8, we study the link between exposure to elite peers in high school to earnings at ages 30-32 and use the sub-sample born between 1986 and 1988.[13]

Data on individuals' education attainment comes from the national education database, which contains codes for the highest completed level of education.[14] We use this information to define our main outcome variable $Y_{isc}$ as an indicator for whether student $i$ entering high school $s$ in cohort $c$ enrols into an elite degree within six years of completing middle school.[15] As mentioned earlier, elite degrees are defined as the set of 5-year bachelor/masters degree in law, medicine, and STEM obtained in the best institutions of the country (see full list of degrees in section 2). Even though high school is only three years long, we define the outcome as enrolling into a degree within

[11]These students were born between 1986-1993.

[12]By far most students starting high school in Norway do this within the Norwegian school system. There is no tradition of attending high school in other countries. Some families will of course move to another country during high school, and we lose track of them in the data, but this is negligible.

[13]Bhuller, Mogstad and Salvanes (2017) suggest rank stability of earnings from age 30.

[14]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.

[15]We focus on enrolment in elite degrees as opposed to completion of an elite degree as our main outcome because our interest in this paper lies in how peers shape subject choice. Peers could also shape students' ability to complete the degree they enrol in, but studying this mechanism is beyond the scope of this paper.

six years of completing middle school because it is very common in Norway to have one or two gap years between high school and university in order to travel, work or complete military service (which has been mandatory for men and women since 2015).[16]

Our data set contains school identifiers and links students' educational records to a rich set of information on their parents, including parental education, occupation and income. We define the student's peer group as all students entering the same high school in the same year, and we construct our main treatment variable, $P_{-isc}$, as 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).[17]

In all regressions we control for a set of covariates relating to the individual student or their parent, which are all predetermined with respect to the student entering high school. Individual student controls include an indicator for their gender; whether they were born in Norway and their middle school GPA (standardised within cohorts to have a mean of 0 and standard deviation of 1). Controls about the student's parents include indicators for whether the mother and the father's highest levels of education are compulsory education, high school degree, or university/post-graduate degree; a variable measuring whether the student's has zero, one or two elite educated parents and an indicator for whether the student's household is in the richest decile (based on the distribution across all cohorts in our sample of household income distribution measured at the end of middle school and deflated to 2020 prices).

Throughout the paper, we distinguish between two groups of students with different socioeconomic status, based on the education of their parents. We define the first, 'low SES' group of students as those students 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 students with at least one parent with an elite education (and no parent with no further education beyond compulsory education). We also present our main results for the intermediate SES group in section 5, though we focus most of the discussion on the low and high SES groups for expositional simplicity.

Table 1 provides summary statistics for the individuals in the full sample in the first column,

[16] 2% of the sample of students with a degree in STEM, law or medicine study for the degree abroad but as it is not possible to link the institution, these students are excluded from our sample.

[17] Note that we use the same grouping of elite education for students and parents since these elite groups have been stable over time in terms of being very competitive to enter and a basis for recruitment to top positions in the labour market, paying top salaries (see Strømme and Hansen 2017).

and in the low and high SES sample (as defined above) in the second and third columns. Our sample has close to 178,000 students studying in 556 high schools spread throughout Norway. 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.

The second and third columns of Table 1 compare the probability of enrolling in a higher education degree between 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 students in 'low education' households to 95% among students in the 'elite education' households.[18] 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 for high SES students than for low SES ones. These patterns align with Bütikofer, Risa and Salvanes (2021), whose findings suggest that, although Norway has one of the lowest intergenerational income elasticities in the world, intergenerational education persistence high and comparable to other countries, including the US, with much lower level of income mobility.

The statistics reported in Table 1 also show that there is an important social gradient in the exposure of students to elite peers. On average, low SES students belong to high school cohorts with 4.7% of the parent body with an elite education. This proportion is twice as high for high SES students. This differential exposure to elite peers is unsurprising given the high school admission system in Norway which is conducive to segregation of students based on ability (in municipalities with free choice) or income (in municipalities with catchment areas). At face value, this social gradient in exposure to elite peers could be a reason behind the social gradient in elite degree enrolment observed in the data. Of course, this is only true if elite peers have a positive and equal impact on the likelihood of enrolling in an elite degree for low and high SES students, an assumption we believe has not been verified before. The first objective of this paper will be to identify such impact.

Moving further down through Table 1, the statistics also show that high school students are

[18] Note that about 50 percent of a cohort attend vocational high school, and by far most of the are recruited from low SES background.

disproportionately female (60%) and selected on family income, as 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 deviations above the GPA of the average middle school students (we standardised the middle school GPA distribution to have mean zero and standard deviation 1 in each full cohort of middle school students).

An important component of the paper is to explore the mechanisms behind the estimated peer effect on elite enrolment, focusing on the high school GPA (see section 2 for full details of the high school assessment procedures). High school GPA is an average of teacher, written and oral assessments for each subject taken across the three years of high school, and is the score used by the central admissions system to allocate students to university courses. The GPA is standardised within each cohort to have a mean of 0 and standard deviation of 1. Average high school GPA is therefore close to 0 in the full sample and low (high) SES students perform below (above) the average.

To measure the effect of elite peers on longer run outcomes, we use data on market income (before taxes and transfers) for at least some years between the ages of 30 and 32 for the oldest cohorts of our sample born between 1986 and 1988. Our last year of earnings data is measured in November 2018, so for those born in 1986 income data is available at the full age range of 30-32; whilst for those born in 1988 income is available at age 30. To smooth out the transitory component of income as much as possible, for each individual we calculate the mean income across the available years (where again income is deflated to 2020). To analyse the effect of exposure to elite peers on long run outcomes, we calculate the student's percentile rank of income within each birth cohort.[19] Whilst the average percentile rank of students in the total sample is 58, low SES students in our sample reach on average the 55th percentile, whilst high SES students reach the 65th percentile.

To estimate intergenerational mobility regressions, for each student, we calculate parents' percentile rank of income by taking the average of real household income between ages 15-19, the ages where the students make decisions about the pursuit of elite education (see Chetty et al. 2020*b*). This is calculated for all parents whose children were born during our sample period 1986-1993 (not just those choosing an academic high school track). The percentile rank of income is calculated

[19] To be clear, to compute the sample members' income rank, we use data on the full birth cohort (and not only our sample members).

across the population of parents.

Finally, in a sensitivity analysis presented in section 5, we make use of two indicators of the socioeconomic status of high school peers' parents - the proportion of peers' parents in the top decile of the income distribution (measured similarly to the own parents by summing income of mothers and fathers at the end of middle school, deflated to 2020) and the proportion of peers' parents working in an elite occupation - as a lawyer, doctor or in a STEM occupation using the same occupation classification used to define local intergenerational mobility. As with the elite peer variables, there is a social gradient in these variables: 23% of peers' parents are positioned in the top of the income distribution in the low SES group versus 31% in the high SES group, 1.4% of them work in elite occupations in the low SES group versus 2.3% in the high SES group.

## 4 Empirical strategy

We start the analysis by estimating the effect of exogenously increasing $P_{-ics}$, the proportion of elite educated parents in student $i$'s cohort $c$ in high school $s$. Our strategy identifies this effect from within school, between cohort variation in outcomes and the proportion of elite peers in the student's cohort. 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 an indicator for whether student $i$ in school $s$ and cohort $c$ enrols 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, excluding student $i$; $X_{ics}$ is a vector of student $i$'s characteristics (gender, Norwegian born, middle school GPA, mother and father's education, proportion of own parents with an elite degree and family income in the top decile); $\alpha_s$ is a school indicator; $\rho$ is a cohort effect; and $\epsilon_{ics}$ is an error term.[20] We cluster standard errors at the school level to account for unobserved correlation of error terms within schools and follow Hoxby (2000) in weighting regressions by school size to take account of the parent peer variables group averages,

[20] In a sensitivity analysis we estimate a model in which the proportion of elite educated peers is included as a quadratic function.

taken from groups of different sizes.

In equation (1), the parameter of interest is $\beta_1$. 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 equation (1) to yield valid causal estimates of $\beta_1$, the key identifying assumption is therefore that cohort-to-cohort variation in the proportion of elite educated parents is random within schools.

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 and on the student's distance to the school in a small number of schools. In schools where admission is GPA-based, variation in $P_{-ics}$ comes from year-to-year variation in parental education of students whose middle school grades 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 schools where admission is distance-based, 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.[21]

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 then half to 0.026, once we remove school and cohort effects,

[21] Our identification strategy may not be valid for areas with particularly small schools, where it is possible that students move together from a shared middle school to a shared high school. In subsection 5.3, we re-estimate our benchmark specification in a sample exclusion schools in the bottom decile of school size (where there are on average 31 students per cohort) and show that estimates are robust to doing so.

leaving sufficient variation for identification. All our estimates are very precisely estimated.

The second potential concern with this identification strategy arises if the proportion of elite peers is correlated with unobservable time-varying determinants of students' outcomes. This could happen if trends in the proportion of elite peers affect the selection of new families into the school, or if elite families systematically select schools based on trends in student outcomes. For example, if highly educated parents move closer or encourage their children to apply to schools with improving outcomes (e.g. because of improvements in management and/or teaching quality over time), then the proportion of elite educated parents $P_{-ics}$ will be correlated with time-varying unobserved inputs driving such trends in outcomes $\epsilon_{ics}$, and the parameter $\beta_1$ 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 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 as characteristics 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. As we will discuss in subsection 5.3, 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 time-varying unobservable, individual determinants of achievement.

Second, we re-estimate our main model in equation (1) 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 $s$. If the results of our benchmark specification are similar to those of our main model, then it will indicate that it is unlikely that elite families select into high schools based on outcome trends.

Of course, a limitation of this second test is that time trends in outcomes may not be captured by the linear term well. We therefore perform a third robustness check, first proposed and referred to as 'drop if more than random' in Hoxby (2000). This check consists in re-estimating equation (1) on the sample of schools excluding those where within school, between cohort variation in $P_{-ics}$ is greater than what would be observed if such variation was random.[22]

As we discuss in subsection 5.3, the results obtained in these two robustness checks are very similar to the estimates of the benchmark model estimated on the full sample, which provides confidence that our identifying assumption holds in this context.

As a final check to ensure that our estimates are not confounding changes in the unobservable characteristics of families across cohorts that are systematically correlated with trends in $P_{-ics}$, we estimate a version of our model with family fixed effects, in addition to school and cohort fixed effects:

$$Y_{iscf} = \lambda_1 P_{-icsf} + \lambda_2 T_{icsf} + X'_{icsf}\lambda_3 + \alpha_s + \rho_c + \mu_f + \epsilon_{icsf} \tag{3}$$

where $f$ denotes the family and $\mu_f$ the family fixed effect. This model identifies the elite peer effect measured by $\lambda_1$ by exploiting within-family variation in cohort-to-cohort variation in the proportion of elite peers within schools. The identifying assumption is weaker than in the setting without family fixed effects, as we must only assume that the unobservable family-specific characteristics that are correlated with the time-varying characteristics of schools families care about are constant across siblings. The results presented in subsection 5.3 will suggest that even removing any variation within-family leads to similar estimates to equation (1).

[22]To conduct this exercise, we first regress for each school the proportion of elite peers on a constant and a quadratic in years, estimating the school-specific time trends. Next the cohorts for each school are randomly reordered five times. If the reordering of cohorts results in the original ordering, the process is repeated until the new ordering does not reflect the true order. After each random reordering, the regression of the proportion of elite peers on a constant and a quadratic in years is repeated, thereby estimating the time trends that would occur if cohorts were randomly assigned within a school. Following Hoxby (2000), if the $R^2$ of the regression using the true cohorts is 1.05 times the smallest $R^2$ of the five regressions with false assignment of cohorts, then the school is flagged as having changes in the composition of elite peers as "more than random". The benchmark estimation is then repeated on the sample of schools which have not been flagged.

## 5 Elite peer effects on elite degree enrolment

### 5.1 Benchmark results

The estimates of equation 1 for the full sample are reported in Table 2. Across all students (column 1), exposure to elite social networks significantly increases average students' enrolment 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 (ppts) increase in the likelihood that students in this school-cohort enrol in an elite degree. Columns (2) and (3) of Table 2 report the estimates of $\beta_1$ 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 different from each other. These estimated peer effects are economically significant, comparing to around one third of the size of the gender differences in enrolment (see Table A3 for the full set of results).

Whilst in Table 2 we report estimates for the low and high SES households, the first panel of Figure A3 plots the estimates and 95% confidence intervals for the sample of low SES, medium SES and high SES households, where the 'medium SES' group includes students where neither parent left school at the compulsory age or has an elite education.[23] The coefficient for households with the medium SES background is in between the coefficients for low and high SES households.

### 5.2 Contribution of elite peer effects to the SES gradient in elite degree enrolment

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.[24]

To measure the contribution of these two sources of disadvantage to the SES gap in elite

[23] As mentioned in section 3, the 'low SES' group of students as those with at least one parent with no further education beyond compulsory education (10 years of education) and no parent with an elite education. The 'high SES' group is the group of students with at least one parent with an elite education (and no parent with no further education beyond compulsory education). The 'medium SES' group includes all students in the full sample who are neither in the low SES nor in the high SES sample.

[24] See section A1 for heterogeneity by gender which shows that the SES gaps exist within gender, but also across gender as the elite peer effect is larger for male students than females.

education enrolment, we perform an Oaxaca Binder decomposition of the gap in elite education enrolment between low and high SES students using the estimates of equation (1). To perform this decomposition, we re-estimate the benchmark model estimated on the sample pooling the low and high SES subsamples and use the estimates of the model to compute the SES gap in elite degree enrolment that is attributable to the average SES gap in the explanatory variables and to the SES gap in the coefficients associated with these variables.

The estimates of this decomposition are reported in Table A4 and show elite peers in high school explain 2.5 ppts or 12% of the SES gap in elite degree enrolment overall. This is driven by the SES gap in the average share of elite peers in high school, which explains 1.5 ppts or 7.2% of the SES gap in elite degree enrolment, and the SES gap in the *effect* of students' exposure to elite educated families, which explains 1 ppt or 4.8% of the SES gap in the outcome.

To get a sense of the relative importance of elite peers in explaining the SES gap in elite degree enrolment, we present the results of the decomposition for a selected set of covariates included in the model in the same table. For example, the SES gap in middle school GPA explains 5 ppts or 24% of the SES gap in elite degree enrolment. The SES gap in the number of elite educated parents the student has (which is 0 in the low SES sample and 1 or 2 in the high SES sample, by construction) explains over half of the elite degree enrolment.

### 5.3 Validity of identification strategy

As described in section 4, we perform a number of checks to probe the validity of our identification strategy. Table A5 reports the results of our placebo checks. Specifically, each row reports the coefficient on the elite peer variables in Equation 1 where the dependent variable is a different birth outcome. As expected, the exposure to elite peers during high school is unrelated to outcomes measured before high school. We take this as encouraging indication that our treatment variable is unlikely to be correlated with unobserved student characteristics which could affect their educational outcomes.

Next, we re-estimate our main specification augmented with school-specific linear trends according to the specification in Equation 2. The results of this specification, which are reported in column (2) of Table 3, are very similar to those from our benchmark specification (included in the first column of the table for easy comparison). The third check that we perform is the 'drop if more than random' check, whereby we re-estimate the model on the sample of schools for which the cross-cohort variation in the proportion of elite families across cohorts is in-line with variation from a random or fictitious ordering of cohorts. The estimates of the model on this sample, reported in column (3) of Table 3, are also very similar to those obtained on the whole sample (reported in Table 2).

Finally, we estimate Equation 3 which restricts variation in treatment to within-family cross-cohort variation in the within-school proportion of elite educated peers by including additionally a family fixed effect. Column (4) of Table 3 reports the results which, although less precisely estimated for the low SES sample are reassuringly similar to the benchmark estimates. Overall, the results of all four of these robustness checks provide strong confidence in the validity of our empirical strategy.

### 5.4 Non-linearities in elite peer effects

Given that low SES students are, on average, less exposed to elite families in their high school than their high SES counterparts, the presence of increasing marginal returns to being exposed to elite families in high school could lead us to estimate a lower average treatment effect for the low SES group than for the high SES group. Several papers in the related literature have shown empirical evidence of non-linearities when considering the effects of high achieving peers, and it is important to test whether it is the case here too.[25] To do that, we re-estimate our main model, this time allowing the effect of elite peers to enter quadratically in the following specification:

$$Y_{isc} = \beta_{11} P_{-ics} + \beta_{12} P_{-ics} \times P_{-ics} + X'_{ics}\beta_2 + \alpha_s + \rho_c + \epsilon_{ics} \tag{4}$$

In Figure A1, we plot the marginal effect of the proportion of elite families as implied by the estimates of this specification (The estimates of the coefficients $\beta_{11}$ and $\beta_{12}$ used to compute these marginal effects are reported in column (5) of Table 3.). The graph overlays these marginal effects over the densities of the elite peer variable in each of the samples to show that there is common

[25] 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 ability distribution.

support for most of the distribution of the treatment variable. Overall, there is little evidence of non-linearity in the effect of the proportion of elite families on students' outcomes through most of the distribution of the treatment variable. The one exception is for the high SES group, for whom the coefficient on the square of the elite peer variable is negative and statistically significant and the non-linearity kicks in at particularly high levels of exposure to elite peers. Importantly, across the distribution of proportion of elite families, the peer effect is higher for high SES students, which confirms that the socio-economic gradient in the elite peer effect reported in Table 2 is not driven by non-linearity in the effect of elite peers.

### 5.5 Other robustness checks

**Sensitivity of results to sample selection** We next examine the extent to which our results are robust to changes in the sample composition including first born children and schools with different admission mechanisms. First, the effect of exposure to elite educated peers may be different for first born children compared to the total sample, if for example children of higher birth order are more influenced by their older sibling than their school peers and their parents (Black, Devereux and Salvanes, 2005*a*). Column (2) of Table A6 suggests this is not the case, as the benchmark estimates are very similar to estimates on the sample of first births.

**Measurement error in the elite peer variable** The incidence of marital breakup may be different across household socioeconomic status and it is possible that the rates of divorce or separation vary across the SES status of schools. This would cause a problem in our estimation as the treatment could have more measurement error in the low SES sample because it is based on all biological parents. Therefore the difference in coefficients between low and high SES may be driven by attenuation bias. We confirm that this is not a problem in Column (3) of Table A6 which restricts the sample to households who have not experienced divorce or separation by the year the student finishes middle school.

**Credit constraints** As argued earlier, the lack of tuition fees and wide availability of student grants and loans means that differential access to credit between low and high SES families is unlikely to be driving the SES gap in elite degree enrolment in the data. Nevertheless, it may be the case that for students attending high schools outside cities where elite degrees are offered, there are additional costs associated with moving to and finding accommodation in these cities. If low SES students do not have as many acquaintances or relatives in these cities as high SES students do, then this type of credit constraints may be one mechanism behind the SES gap in elite degree enrolment that the covariates included in the model do not control for.

To tease out the extent to which this is plausible, we re-estimate the model excluding students attending high school in Oslo. Oslo is the largest municipality in Norway, containing elite universities and a high exposure to elite educated families, and it is where this sort of mechanism is more likely to be at play. Column (4) of Table A6 show that the results are robust to this exclusion. These results also show that our benchmark results are not driven by students within Oslo naturally attending their local elite universities.

**Small schools** Our identification strategy may not be valid for areas with particularly small schools, where students may move together from a shared middle school to a shared high school. Column (5) of Table A6 suggests that our benchmark estimates are robust to dropping schools in the bottom decile of school size (where there are 31 or fewer students per cohort).

As mentioned previously counties across Norway differed in their admissions procedure for high school between a local catchment area and, more commonly competition based upon middle school GPA. Our benchmark analysis was repeated separately by the procedure for admissions to high schools but the results are almost identical in the two samples. For the full sample, the coefficient on treatment of the proportion of parents with an elite degree is 0.027 (standard error 0.004) and 0.026 (standard error 0.005) for areas with local catchment and school choice admissions, respectively.

### 5.6 Interpretation of the elite peer effect

Elite peers are, on average, of higher ability and from families with high levels of income or with parents working in high status occupations. In order to start exploring the mechanisms underlying the elite peer effect, in this section we shed light (descriptively) on the extent to which the peer effect we identify is driven by the fact that these peers have parents with an elite education - as opposed to other, correlated characteristics.

First, we re-estimate the benchmark model (1) this time also controlling for the proportion of peers whose family income is in the top decile of the national distribution and for the proportion of peers whose parents work in elite occupations (i.e working in a STEM occupation or as a doctor or lawyer). The results of this specification are reported in column (6) of Table A6 and show that the elite peer effect we have focused on so far is very robust to the inclusion of these other peers' characteristics, suggesting that the elite education of the peers' parents is likely to be driving the results we find.

Second, the elite peer effect might also pick up the effect of exposure to peers with a higher level of academic achievement. However this is not the case, as when the treatment variable is replaced with a measure of peer ability - the leave one out peer mean of the middle school GPA - there is a negative effect of an exogenous increase in mean peer ability on enrolment to elite education.[26] This suggests firstly that our peer effect is not just picking up exposure to high quality peers, but also that adding an elite peer to the cohort can work against enrolment to elite education, possibly through a reduced confidence or self-esteem as suggested by Cools, Fernández and Patacchini (2019).

## 6 Elite peer effects on students' academic performance

Having established the presence of a significant elite peer effect on elite degree enrolment and a socioeconomic gradient in this effect, we turn to exploring the mechanisms underlying this effect. As explained in section 2, student's enrolment in an elite degree is determined by whether they apply to such a degree and by their high school GPA. In this section, we ask whether and why elite peers affect high school GPA.

### 6.1 Elite peer effects on overall GPA and its sub-components

We start by estimating the elite peer effects on overall GPA by estimating equation Equation 1, this time with high school GPA as dependent variable. The estimates of these models are reported in Panel A of Table 4 and show that an increase in the proportion of elite peers in a student's school cohort has a negative and statistically significant effect on overall GPA across the whole sample. Coefficients in the second and third column of the table reveal a strong socio-economic gradient in

[26] The coefficients (standard errors) for the low and high SES students are -0.014 (0.003) and -0.050 (0.018) respectively.

this effect. Specifically, exposure to elite peers have a significantly detrimental effect on the GPA of low SES students, reducing their grade by 17.1% of a standard deviation and a smaller detrimental effect on the GPA of high SES students of 4.6% of a standard deviation. Given the fact that high school GPA plays a central role in university admission in Norway, this negative effect of elite peers on the GPA of low SES students provides part of the explanation for why elite peers have a lower effect on low SES students than on high SES students' probability to enrol in an elite degree.

As explained in section 2, overall GPA is a weighted average of blindly assessed written exams, teacher-assessed internal grades, and oral exams assessed by the student's teacher and an external examiner. To understand the mechanisms underlying the effect of elite peers on overall GPA, we re-estimate the model this time with each GPA component as dependent variable (Panel B of Table 4). On average, exposure to elite peers in high school *increases* grades on externally-assessed written exams for both high and low SES students. In contrast, exposure to elite peers *decreases* the grades of low SES students on exams assessed by teachers either fully (internal grades) or partly (oral exams). Exposure to elite peers also lowers the teacher assessment of high SES students, but the coefficient is a quarter the size as for low SES students. For high SES, there is no statistically significant peer effect on oral exam grades. All in all, the negative effect of elite peers on overall GPA is driven by the negative effect of elite peers on the exams that the teacher assesses.[27]

We can think of two explanations for this teacher downgrade. First, consider a low SES student who has a high ability level, but lower than their elite peers. As an elite peer is added to the student cohort, the teacher may downgrade their assessment of the low SES student if they assess each student's ability relative to the cohort as a whole.[28] Second, teachers have an implicit bias against low SES students and this is exacerbated by a higher proportion of elite students. For example, it may be that the low SES students have weaker communication or socio-emotional skills compared to the high SES students, and exposure to more elite students highlights this difference.

To tease out these possible explanations for the negative effect on teacher assessments, Table A7 replaces the dependent variable from Table 4 to measure the percentile rank of the student's high

[27]In the final three panels of Figure A3 the coefficients on the effect of exposure to elite peers on overall GPA and its components are plotted for low, medium and high SES households. On the whole, the peer effect for middle SES households sits in between estimates for low and high SES households, suggesting a linear SES gradient, although the confidence intervals often overlap across samples. The exception is for the written assessment where the exposure to elite peers has the same coefficient across household socioeconomic background.

[28]Teachers are not officially supposed to mark to a curve, but may nonetheless grade students relative to others.

school GPA amongst their high school peers. For all GPA components, there is evidence that exposure to elite peers lowers the student's rank of their GPA, even though we saw in Table 4 a positive peer effect on the written exam score. This suggests that the negative effect of exposure to elite peers on the students' teacher assessment may be due to the teachers' perception that the remaining students are of a lower ability compared to the elite student.

Next we present in Figure A2 estimates of the elite peer effect on teacher assessments, this time allowing an interaction between the peer effect and the student's ability rank within the cohort, where the rank is calculated using the middle school GPA, ranked across all students within the same high school cohort. The figure clearly shows that the negative effect of the exposure to elite peers on the teacher assessment is driven by lower ranked students within the cohort. Still, teachers marking to a curve cannot explain the full story as there is a SES bias. The downgrade in the teacher assessment from elite peer exposure at a given rank is always larger for low SES students than high SES students.[29]

These results are consistent with a body of evidence which indicates that teacher assessments are subject to a large and significant level of error and, more importantly, that there may be systematic patterns of inequality in teacher judgements. For example, using administrative data, Burgess and Greaves (2013) and Lavy (2008) compare "blind" and "non-blind" assessment methods in English and Israeli schools, respectively and find systematic and quantitatively significant differences in blind/non blind test scores across ethnic groups and genders, respectively. Combining survey data on teacher perceptions of pupils' ability and independent measures of pupil test performance, Campbell (2015) finds evidence that teachers systematically under-rate low-income pupils in English schools. Finally, Alesina et al. (2018) and Carlana (2019) show that teachers have stereotypes that create systematic differences in the way they grade similarly able students, based on whether they are immigrants or native students and based on the student's gender, respectively. They elicit these stereotypes using Implicit Association Tests.

The evidence presented in Table 4 is consistent with the existence of a systematic teacher bias against low-SES students, but it goes further in showing that the extent to which teachers systematically bias against them is endogenous and responds to school composition. Specifically, the higher the fraction of elite peers in the cohort, the stronger the bias in teachers' assessment

[29] Recall, we always condition on the student's own middle school grade.

against low SES students.

## 7 Mediation analysis

The analysis so far has shown that exposure to elite peers increases the probability that students enrol in an elite degree, but decreases their GPA. This implies that, conditional on high school GPA, exposure to peers from elite families must have a positive effect on students' likelihood to apply to elite degrees through channels such as by providing information or acting as a role model. In this section, we quantify the contribution of these two channels to the overall effect of elite peers on the probability to enrol in an elite degree. Because the estimated peer effect for low SES students on enrolment is relatively low, whilst on their GPA is relatively high, we focus on the low SES students but report results for high SES students for information. Indeed, the objective is to understand whether it is possible to raise the effect of exposure to elite peers for low SES students, by removing the negative effect through the channel of high school GPA.

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

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

where the coefficient $\gamma_1$ is the direct peer effect of elite families conditional on GPA through information or role model channels. $\gamma_2$ is the effect of $GPA$ on the probability of enroling in an elite degree. A naive estimation of equation (5) by OLS would not identify $\gamma_1$ because, as shown earlier, $GPA_{ics}$ is correlated with $P_{-ics}$ and it is likely to be correlated with unobserved individual determinants of elite degree enrolment (and hence endogenous). In order to identify $\gamma_1$ and $\gamma_2$ in an unbiased way, we therefore need to instrument $GPA_{ics}$ in equation (5). This exercise can be seen as a causal mediation analysis with endogenous mediators discussed in Celli (2021).[30]

To instrument high school GPA, we exploit a unique feature of the Norwegian high school system, whereby a lottery randomly allocates students to take externally assessed examinations in a specific subject in years 2 and 3 of high school. Specifically, we instrument $GPA_{ics}$ with

[30] There are a few examples of mediation analysis taking account of the endogeneity of mediators through an instrumental variables strategy in the economics literature. For example, see Aklin and Bayer (2017), Attanasio et al. (2020), and Nicoletti, Salvanes and Tominey (2022)

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. Maths is one of the most important subjects required for admission to elite degree programmes.[31] The randomisation takes place within the general high school programme (for example within the social science programme) and as such, we will control in all IV analysis for high school programme of study indicators.

The instrument satisfies the rank condition since, by nature, the randomisation should be orthogonal to any unobservable determinant of achievement (and we have school and programme of study fixed effects in the regression to account for the fact that randomisation is done within schools and programme of study). We provide supporting evidence of this in Table A8, which reports the coefficients (and standard error) of a regression of the instrumental variable on the set of covariates included in the benchmark specification, augmented by indicators for programme of study in high school (including social science, humanities, science and general), school and cohort fixed effects. The table shows very little significance of student characteristics in prediction of the lottery assignment to take a maths exam.

We estimate Equation 5 jointly with the following first stage equation:

$$GPA_{ics} = \delta_1 P_{-ics} + Z^{'}_{ics}\delta_2 + X^{'}_{ics}\delta_3 + \alpha_s + \rho_c + \epsilon_{ics} \tag{6}$$

where $Z$ denotes the instrumental variable and the notation for other terms is as before. The direct effect of exposure to elite peers on student enrolment is the conditional effect given by coefficient $\gamma_1$. The indirect effect of exposure to elite peers through the channel of high school GPA is the product of $\delta_1$ from equation 6 and $\gamma_2$ from 5 (i.e. the product of the effect of elite peers on high school grades and the effect of high school grades on elite enrolment).

The OLS and IV estimates are reported in Table 5 (the OLS estimates corresponds to the benchmark Equation 1 where we also control for the additional high school programme indicators). Panel A reports the first stage and confirms that the instrument is relevant for the low SES student sample only where the F-statistic on the instrumental variable is 16.23. The F-stat for the high SES sample is much lower at 5, which is intuitive since high SES students perform very highly anyway and there was a lower downgrade in teacher assessments for these students. For this reason

[31] Burgess et al. 2022 show in Denmark that being randomised to take an additional semi-blind examination in mathematics can close the gender gap in entry to STEM degrees.

we now focus on reporting the results for low SES students.

Panel B of Table 5 reports the IV estimates of Equation 5. As expected, high school GPA has a strong positive and statistically significant effect on the probability of enroling in an elite degree. The coefficient on the elite peers in the IV specification is 0.038 and statistically significant in the low SES sample, which means that an increase in exposure to elite peers by one standard deviation encourages low SES students to raise their enrolment in elite degree by 3.8 percentage points (conditional on GPA). This direct effect is consistent with elite peers (and/or their families) raising students' motivation or aspiration to pursue an elite education over and beyond any effect they have on academic performance, for example by acting as role models and/or providing information on elite degrees and their returns.

The final rows of Table 5 decompose the total peer effect on student enrolment to an elite degree from Table 2 into the direct effect $\gamma_1$ from Equation 5 and the indirect effect $(\delta_1 * \gamma_2)$. Interestingly the effect of exposure to elite peers coming from grades is almost the same magnitude as the effect coming from the other mechanisms of information and role models. The indirect effect of exposure to elite peers on elite enrolment through high school grades reduces enrolment by 2.7 percentage points. This suggests that a policy reform to increase the proportion of written maths examinations assessed blindly for low SES students would reduce the teacher bias from exposure to elite peers and raise enrolment of low SES students in elite degree programmes.[32]

## 8 Does exposure to elite peers reduce intergenerational income mobility?

We conclude our analysis by considering the implications of our results for earnings 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. If the return to studying for an elite degree is very low for low SES students (as it has been shown by Zimmerman (2019) for Chile, for example),[33] then any policies to increase enrolment on elite degree programmes for these students - through increased exposure

[32]The direct effect for high SES students also increases once we condition on high school GPA, however with such a low F-statistic we do not consider these results as reliable.

[33]Zimmerman (2019) shows that the returns to elite degrees in Chile are close to zero for males and females not from private high schools, which are the types of high schools that charge high tuition and serve upper-income households.

to elite educated peers or more blind assessments at school - will not reduce earnings inequalities by SES background.

To shed light on these hypotheses, we use data on the earnings of the three oldest cohorts in our data (born between 1986-1988). For these cohorts it is possible to measure income for some ages between 30 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 (Bhuller, Mogstad and Salvanes, 2017). Using these data, we ask the following questions: First, is the earnings premium from an elite degree similar across student SES background? Second, does exposure to elite peers raise the longer-run outcome of earnings age 30-32? Third, does exposure to elite degrees exacerbate or mitigate the link between child and parents' earnings?

We first investigate the association between an elite degree and earnings for the two subsamples of low and high SES students. To do so, we estimate a Mincer style regression of earnings on an indicator for whether the student enrolled in a degree and an indicator for enrolling in an elite degree (with the category of no degree is omitted) on 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 6 in columns (1) and (2) where the dependent variable is the (within cohort) percentile rank of earnings age 30-32 in Panel A and an indicator for earning in the richest decile in panel B. In line with Bütikofer, Risa and Salvanes (2021), we find evidence of very high average returns to enrolling in an elite degree.[34] And, in contrast with the findings of Zimmerman (2019) for Chile, the return for low SES students are only slightly smaller than they are for high SES students. Specifically, enrolling in an elite degree increases the percentile rank at 30-32 by 26.7-30.5 percentiles for low and high SES students respectively. From panel B, enrolling in an elite degree is associated with an increase in the probability to earn in the richest decile by 25.0 and 28.4 ppts relative to someone with no degree. The similarity of these coefficients across SES is an interesting finding - which we do not believe had been uncovered before - especially as it appears in great contrast with evidence available for other countries.

Given similarly 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 causal elite peer effect on earnings. To do so, we re-estimate our benchmark equation (1), this time with the

[34] These are descriptive rather than causal returns, estimated through OLS.

indicator for the percentile rank (panel A) and earnings in the top decile (panel B) as outcomes. We present the estimates of this specification in columns (3) through (4) of Table 6. Being exposed to elite peers in high school increases the percentile rank but this effect is lower for low SES students than it is for high SES students (0.86 percentiles compared to 2.5). It also increases the probability of being in the richest decile at age 30-32 but only for high SES students (2.2 ppts). These results are in line with our earlier evidence that elite peers have a less positive effect for low SES students than for high SES students but suggests additionally that the effect of elite peers persists into later life.[35]

Together, these findings show that elite peers increase the educational attainment and earnings of low SES students, but because they have a stronger effect on the outcomes of high SES students, exposure to elite peers may exacerbate the intergenerational persistence in education. To get a sense of how large the effect of such social interactions are on intergenerational income mobility, we estimate intergenerational mobility rank-rank regressions and allow the persistence in earnings across generations to vary across exposure to elite educated peers.[36] An indicator for high exposure to elite peers is defined to take the value of 1 in school cohorts with above mean exposure ot elite peers (with a proportion above 6%) and 0 otherwise. We estimate a regression where the dependent variable is the child's percentile rank between age 30-32, regressed on an indicator for high exposure to elite peers, a quadratic in the parents' percentile rank for the child ages 15-19 and a quadratic interaction between high exposure and the parents' percentile rank.[37]

Figure 2 demonstrates a strong link between the percentile rank of the parent and their child which is strengthened by high exposure to elite peers in the high school cohort. For any value of the parent percentile rank, the child's percentile rank is higher in the high exposure group with above average proportion of elite peers than in the low exposure treatment. Importantly, the additional

[35] The results do not 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). When re-estimating the model this time also controlling for whether the student has enrolled in an elite education (available upon request), we still find a positive effect and an SES gradient 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.

[36] This follows a similar strategy of Pekkarinen, Uusitalo and Kerr 2009, used for example in Bütikofer and Salvanes 2020 and Kaila et al. 2021.

[37] Specifically, the equation we estimate is as follows: $PCT^{student}_{ics} = \phi_1 P_{-ics} + \phi_2 PCT^{parent}_{ics} + \phi_3 PCT^{parent^2}_{ics} + \phi_4 P_{-ics} * PCT^{parent}_{ics} + \phi_5 P_{-ics} * PCT^{parent^2}_{ics} + \phi_6 X_{ics} + \alpha_s + \rho_c + \epsilon_{ics}$; where $PCT^{student}$ and $PCT^{parent}$ denote the percentile rank of the student (30-32) and the parent (child aged 15-19) respectively.

uplift in the relationship is highest at the bottom and the top of the parent income distribution. This means that whilst exposure to elite peers may increase mobility for low SES students, it also increases persistence at the top of the income distribution and may therefore contribute towards the particularly high intergenerational persistence in education at the upper tail.

## 9 Conclusion

Socioeconomic inequalities in elite education are high, even in 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 enrolment in elite degrees of students in a way that exacerbates socioeconomic 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. Nevertheless, elite peers also increase mobility for low SES students and may therefore help these students become first generation elite.

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 penalises the GPA of low SES students much more than for 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 behaviour adjusting to the presence of elite peers to the detriment of low SES students.

Second, conditional on GPA, a causal mediation analysis suggests that 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.

As we show in this paper, the very high monetary returns to an elite degree for both low and high SES students 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. 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. Crucially, to increase social network effects for low SES students, our results highlight the need for blind, externally marked assessments of student achievement in the place of teacher assessments.

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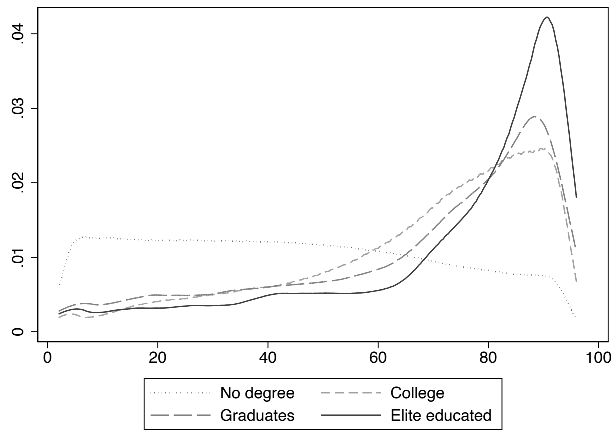
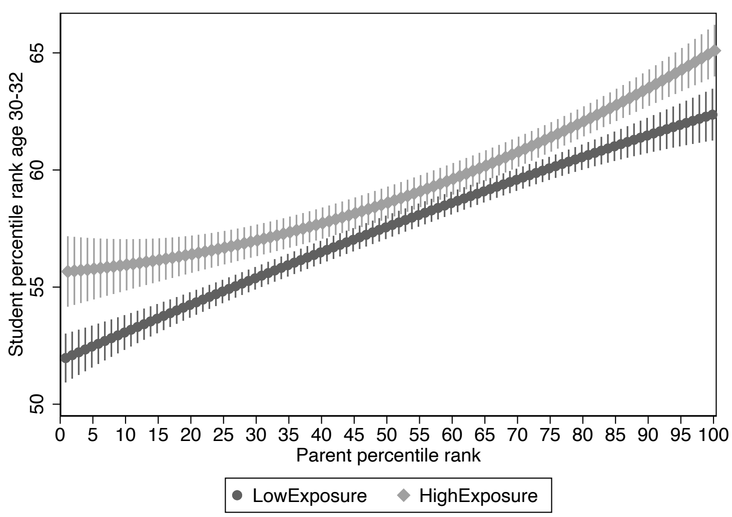
**Figure 1:** Density of earnings percentiles by education level




Notes: This graph plots the density of earnings percentiles across educational groups. Sample is the population of Norway aged 28-40 between 1993-2001. The percentile rank of earnings is calculated within each birth cohort.

**Figure 2:** Intergenerational mobility: estimating the percentile rank-rank correlation across exposure to elite peers




Notes: This graph plots the fitted values from an intergenerational mobility rank-rank regression allowing for the interaction between exposure to elite peers and the parent percentile rank to be quadratic. High exposure is defined as above mean proportion of elite peers in the high school cohort.

**Table 1:** Summary statistics of the sample

| | Full sample | Low SES sample | High SES sample |
|---|---|---|---|
| | Mean (sd) | Mean (sd) | Mean (sd) |
| Enrolls in higher education | 0.904 | 0.861 | 0.956 |
| Enrolls in elite degree | 0.102 | 0.053 | 0.260 |
| % of parent with elite degree | 0.061 | 0.047 | 0.100 |
| | (0.056) | (0.047) | (0.068) |
| **Covariates** | | | |
| 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 |
| | | | |
| % 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) |
| | | | |
| % of peer parents in top income decile | 0.247 | 0.230 | 0.308 |
| | (0.110) | (0.103) | (0.120) |
| % of peer parents in elite occupation | 0.017 | 0.014 | 0.023 |
| **Mechanisms** | | | |
| High school GPA (std) | 0.013 | -0.252 | 0.494 |
| | (0.999) | (0.951) | (1.000) |
| **Long-run** | | | |
| Student in top decile of earnings 30-32* | 0.141 | 0.104 | 0.230 |
| Student percentile rank 30-32 | 58.494 | 55.181 | 64.667 |
| | (26.728) | (25.926) | (28.068) |
| | | | |
| N | 177,219 | 58,328 | 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. Elite degree status defined as enrolment into Business/Engineering, Law of Medicine at a top institution (see section 3). High school GPA is standardized within cohort to have mean 0 and standard deviation 1. Middle school GPA is standardized to have mean 0 and standard deviation 1 within the cohort. % of local elite workers measure the % of workers in STEM, law or medicine occupations whose father was not in a professional occupation. *Measured for oldest 5 cohorts where sample size is 59,043; 20,454; 6,765 for the total sample; low SES and high SES respectively.

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

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

Notes: 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, a variable measuring the number of student's own parents who have an elite education, and an indicator for whether the student's family income is in the top decile of the overall income distribution. Regressions 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. Regressions are weighted by school size to take account of the parent peer variables group averages, taken from groups of different sizes. Standard errors clustered at the school level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

**Table 3:** Validity of the empirical strategy

| | (1) Benchmark | (2) School-specific linear trends | (3) 'Drop if more than random' | (4) Including family fixed effect | (5) Quadratic specification |
|---|---|---|---|---|---|
| **A - Low SES students sample** | | | | | |
| Proportion of parents with elite degree (std) | 0.013*** | 0.013*** | 0.010** | 0.010 | 0.014*** |
| | (0.003) | (0.003) | (0.004) | (0.006) | (0.003) |
| Proportion of parents with elite degree squared | | | | | -0.001 |
| | | | | | (0.001) |
| *Number of pupils* | *58,610* | *58,610* | *28,181 58,610* | | *58,610* |
| *Number of schools* | *524* | *524* | *284* | *524* | *524* |
| **B - High SES students sample** | | | | | |
| Proportion of parents with elite degree (std) | 0.040*** | 0.047*** | 0.038*** | 0.032*** | 0.058*** |
| | (0.008) | (0.008) | (0.013) | (0.012) | (0.010) |
| Proportion of parents with elite degree squared | | | | | -0.008** |
| | | | | | (0.004) |
| *Number of pupils* | *20,018* | *20,018* | *8,420* | *20,018* | *20,018* |
| *Number of schools* | *459* | *459* | *240* | *459* | *459* |

Notes: OLS estimates of the coefficient on the variable measuring the fraction of elite educated parents in the student's youth cohort in different specifications in the low SES sample (Panel A) and in the high SES sample (Panel B). Column (1) refers to the benchmark specification (equation 1) and reported in Table 2. Column (2) refers to the benchmark specification augmented with a quadratic term in the elite peer variable. Column (3) refers to the benchmark specification this time estimated on the subsample of schools where variation in the elite peer variable evolves over time in a random way. Specifically, we drop the schools where the $R^2$ from a school-level regression of the proportion of elite educated peers on a quadratic in year is 1.05 times the $R^2$ from five regressions where cohorts are randomly re-ordered for each. See section 4 for full details. Column (4) refers to the benchmark specification where we also control for a family fixed effect. Column (3) refers to the benchmark specification where we also control for school-specific linear trend. Column (5) refers to the benchmark specification but allowing for a quadratic in the treatment variable. Regressions are weighted by school size to take account of the parent peer variables group averages, taken from groups of different sizes. Standard errors clustered at the school level. Standard errors clustered at the school level. *** p<0.01, ** p<0.05, * p<0.1

**Table 4:** Elite peer effect on overall GPA and its components

| | (1)<br>Full sample | (2)<br>Low SES | (3)<br>High SES |
|---|---|---|---|
| **A - Overall GPA** | | | |
| | -0.118*** | -0.171*** | -0.046*** |
| | (0.013) | (0.016) | (0.012) |
| *Number of observations* | *177,219* | *58,610* | *20,018* |
| | | | |
| **B - Components of GPA** | | | |
| Externally assessed written exam grades | 0.025*** | 0.030** | 0.030* |
| | (0.009) | (0.012) | (0.016) |
| *Number of observations* | *177,219* | *58,610* | *20,018* |
| | | | |
| Teacher-assessed internal grades | -0.110*** | -0.162*** | -0.040*** |
| | (0.013) | (0.016) | (0.012) |
| *Number of observations* | *177,219* | *58,610* | *20,018* |
| | | | |
| Semi-externally assessed oral exam grades | -0.036*** | -0.064*** | -0.012 |
| | (0.008) | (0.011) | (0.014) |
| *Number of pupils* | *149,488* | *49,414* | *17,189* |

Notes: OLS estimates of the effect of the proportion of parents with an elite degree in the student's school cohort in the benchmark model where the dependent variable is now a measure of academic performance. See notes to Table 2 for detailed list of controls. The measures of academic performance are: overall high school GPA (row 1), average performance on externally assessed written exams across all three years of high school (row 2), average performance on teacher assessed grades across all three years of high school (row 3), and average performance on oral exams marked by an external examiner and the student's teachers across all three years of high school (row 4). All measures of performance are standardized to have mean 0 and standard deviation 1 within cohort. 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. Standard errors clustered at the school level. *** p<0.01, ** p<0.05, * p<0.1

**Table 5:** IV estimates and decomposition of the total effect of elite peers on elite degree enrolment

| | Low SES | | High SES | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | OLS | IV | OLS | IV |
| **A - Dependent variable: GPA** | | | | |
| Proportion of parents with elite degree (std) | | -0.039*** | | -0.009 |
| | | (0.007) | | (0.010) |
| Student took written math exam (IV) | | 0.031*** | | 0.029** |
| | | (0.008) | | (0.013) |
| *F stat* | | *16.23* | | *5.00* |
| **B - Dependent variable: elite degree enrolment** | | | | |
| Proportion of parents with elite degree (std) | 0.010*** | 0.038*** | 0.032*** | 0.054*** |
| | (0.004) | (0.008) | (0.006) | (0.024) |
| Overall high school GPA | | 0.690*** | | 2.273** |
| | | (0.172) | | (0.970) |
| **C - Decomposition** | | | | |
| Direct effect | | 0.038 | | 0.054 |
| Indirect effect | | -0.027 | | -0.020 |
| Total effect | | 0.011 | | 0.034 |
| *Number of pupils* | *58,586* | *58,586* | *19,968* | *19,968* |
| *Number of schools* | *500* | *500* | *409* | *409* |

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 in years 2 or 3 of high school. Dependent variable is indicator for studying for an elite (graduate) degree. Model controls the same as Table 2 including school, cohort and high school program fixed effects. Regressions are weighted by school size to take account of the parent peer variables group averages, taken from groups of different sizes. Standard errors clustered at the school level. *** p<0.01, ** p<0.05, * p<0.1

**Table 6:** Long-term implications for earnings

| | (1)<br>Low SES | (2)<br>High SES | (3)<br>Low SES | (4)<br>High SES |
|---|---|---|---|---|
| **A - Dependent variable: Earnings percentile** | | | | |
| Student ever enrolled in degree | 10.185*** | 14.369*** | | |
| | (0.455) | (1.574) | | |
| Student ever enrolled in elite degree | 26.701*** | 30.521*** | | |
| | (0.828) | (1.639) | | |
| Proportion of parents with elite degree | | | 0.816*** | 2.462*** |
| | | | (0.344) | (0.615) |
| **B - Dependent variable: Richest decile** | | | | |
| Student ever enrolled in degree | 0.028*** | 0.082*** | | |
| | (0.005) | (0.024) | | |
| Student ever enrolled in elite degree | 0.250*** | 0.284*** | | |
| | (0.010) | (0.025) | | |
| Proportion of parents with elite degree | | | 0.004 | 0.022*** |
| | | | (0.004) | (0.009) |
| *Number of pupils* | *20,454* | *6,765* | *20,454* | *6,765* |
| *Number of schools* | | | *457* | *372* |

Notes: Columns (1) and (2) run a Mincer-style regression of earnings on an indicator for degree and an elite degree. The omitted category is no degree. The low SES sample in columns (1) and (3) 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 in columns (2) and (4) 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. Sample of birth cohorts 1986-1989. Income is deflated to 2020. For the cohorts 1986; 1987; 1988 and 1989 income is measured ages 28-32; 28-31; 28-30 and 28-29 respectively (see section 3). The regressions include controls from Table 2. The variable parent in richest decile is measured by taking average parent earnings when the child is agd 15-19 (deflated to 2020). Standard errors clustered at the school level. *** p<0.01, ** p<0.05, * p<0.1

## Online Appendix

### A1 Gender heterogeneity

There are very well documented differences in college majors across genders which contribute towards the gender pay gap. We re-estimate the benchmark model from Equation 1 separately by gender to understand if the SES gap exists within gender. The results in Table A1 suggest that the effect of exposure to elite educated peers during high school on elite enrolment is larger for males than females (3.9ppt compared to 1.8ppt in the full sample). Within each gender, the SES gradient is still present and the peer effect is considerably larger for low SES males or females compared to high SES males or females.

**Table A1:** Gender differences in effect of elite parent peers

| | (1) All | (2) Low SES | (3) High SES |
|---|---|---|---|
| **A - Sample of females** | | | |
| Proportion of parents with elite degree (std) | 0.018*** | 0.008*** | 0.032*** |
| | (0.003) | (0.002) | (0.008) |
| **B - Sample of males** | | | |
| Proportion of parents with elite degree (std) | 0.039*** | 0.025*** | 0.051*** |
| | (0.006) | (0.005) | (0.012) |
| Number of female pupils | 106,421 | 37,945 | 10,559 |
| Number of male pupils | 70,798 | 20,383 | 9,459 |

*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. Low (elite) education household contains at least one parent with compulsory (elite) education. Upward mobility is gender specific, measuring the % of local elite occupations of the same gender of the student who come from a non-professional background.

A different way to consider at gender is the gender of the parents. Do the elite parent peer effects vary across the % of mothers or fathers with elite degrees? According to Table A2 the peer effects are stronger when the parent with an elite degree is a father, rather than a mother. For boys there is not a statistically significant difference in the peer effect across mothers and fathers whereas for girls there is where again it is the fathers who have the largest peer effect. The exception is the low SES boys.

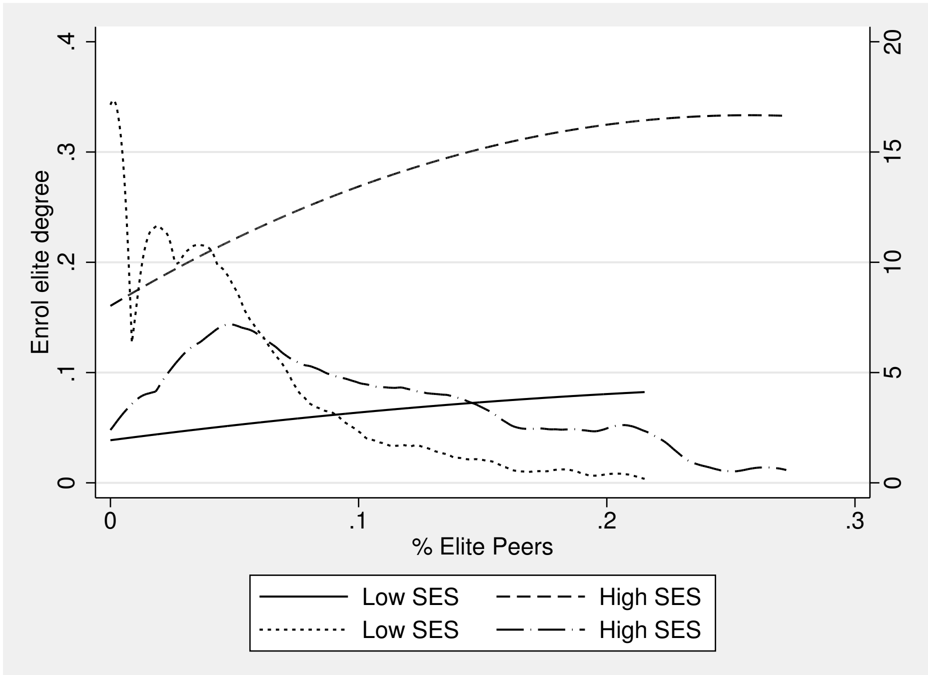
**Table A2:** Gender differences in effect of elite parent peers

| | (1) All | (2) Low SES | (3) High SES |
|---|---|---|---|
| **A - Sample of females** | | | |
| Proportion of mothers with elite degree (std) | 0.005* | 0.000 | 0.006 |
| | (0.003) | (0.003) | (0.007) |
| Proportion of fathers with elite degree (std) | 0.014*** | 0.007*** | 0.028*** |
| | (0.003) | (0.003) | (0.009) |
| **B - Sample of males** | | | |
| Proportion of mothers with elite degree (std) | 0.014*** | 0.014*** | 0.018** |
| | (0.004) | (0.005) | (0.009) |
| | 0.027*** | 0.013** | 0.035*** |
| Proportion of fathers with elite degree (std) | (0.005) | (0.005) | (0.013) |
| Number of female pupils | 106,421 | 37,945 | 10,559 |
| Number of male pupils | 70,798 | 20,383 | 9,459 |

*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. Low (elite) education household contains at least one parent with compulsory (elite) education. Upward mobility is gender specific, measuring the % of local elite occupations of the same gender of the student who come from a non-professional background.

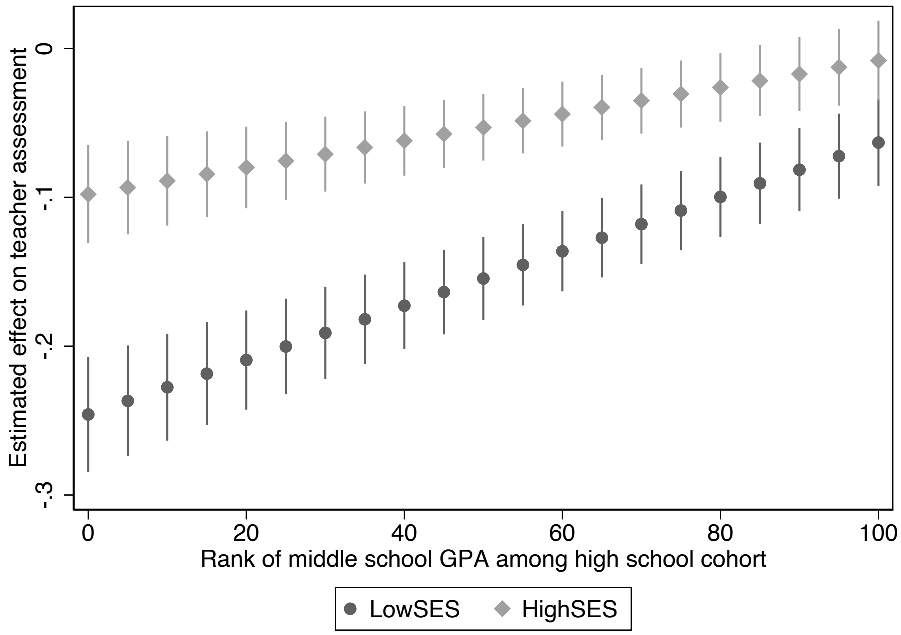
## A2 Additional figures and tables

**Figure A1:** Marginal effect of exposure to elite social networks implied from quadratic specification



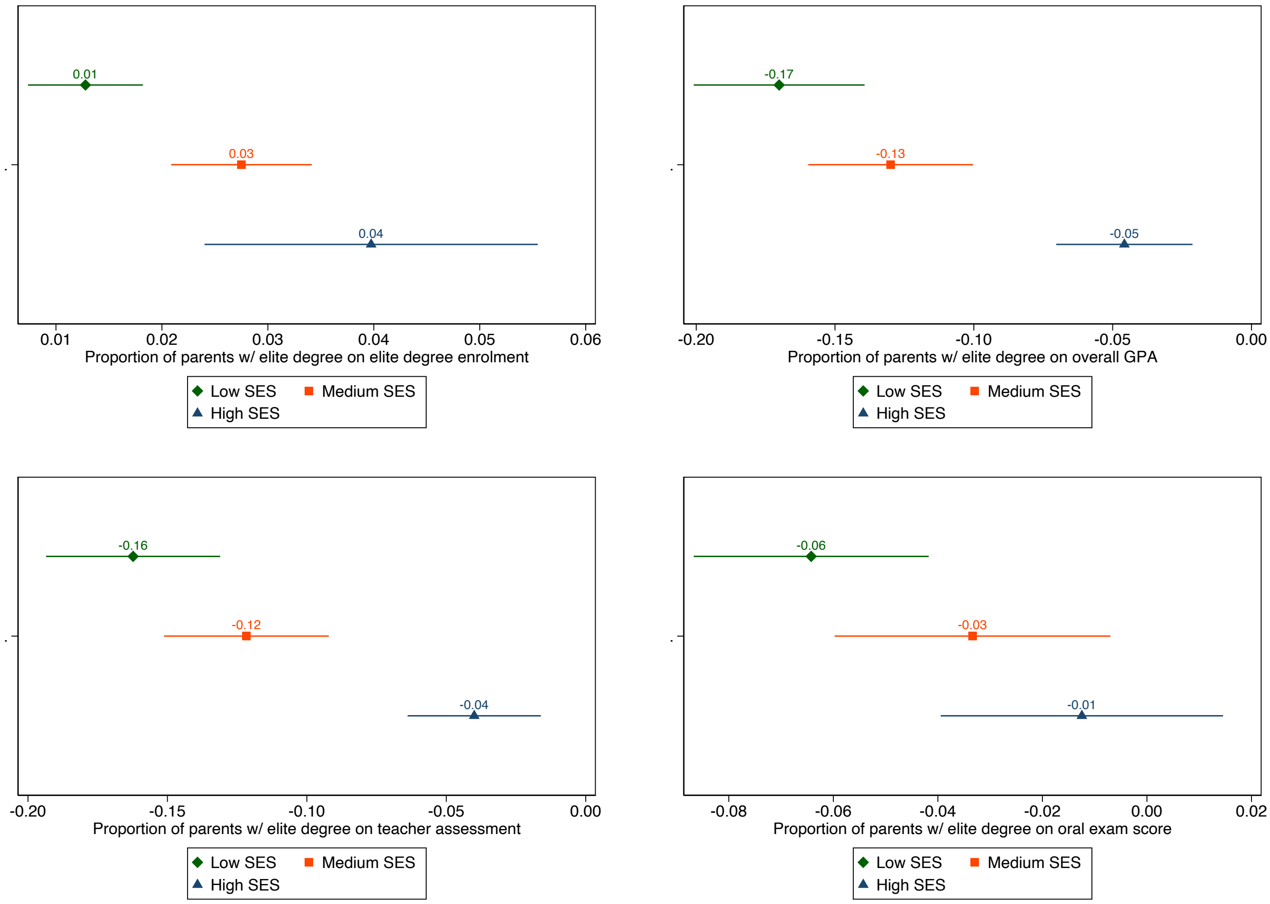

Notes: This graph plots the densities of $P_{-ics}$ in the low SES (dotted line) and high SES samples (dot-dashed line). It also plots the marginal effect of an increase in $P_{-ics}$ on the probability of enrolling in an elite degree as a function of $P_{-ics}$ as implied by estimates of $\beta_{11}$ and $\beta_{12}$ in equation (4). The marginal effect in the low SES (high SES) sample is plotted as a solid (dashed) line. The estimates of these coefficients are reported in Column (5) of Table 3.

**Figure A2:** Marginal effect of exposure to elite social networks on high school teacher assessment across student middle school rank




Notes: This graph plots the marginal effect of an increase in $P_{-ics}$ on the probability of enrolling in an elite degree as a function of the rank of the student's middle school GPA amongst the high school cohort. Estimated on the benchmark specification including the rank of middle school GPA and an interaction between the rank and the proportion of parents from an elite educated background. The marginal effect in the low SES (high SES) sample is plotted as a dark grey circles (light grey diamonds).

**Figure A3:** Effect of exposure to elite peers on student outcomes by socioeconomic background




Notes: This graph plots the marginal effect of an increase in $P_{-ics}$ on student outcomes: the probability of enrolling in an elite degree; overall high school GPA; high school teacher assessment and high school written exams. The coefficients are estimated from regression Equation 1. See notes to Table 2 for details of the specification. 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. The medium SES sample defines households with the education in between - where no parent left school at the compulsory age and no parent has an elite education.

**Table A3:** 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 A4:** Oaxaca Binder decomposition of the SES gap in elite degree enrolment

| | **SES gap in characteristics** | | **SES gap in coefficients** | |
|---|---|---|---|---|
| | Gap | Contribution | Gap | Contribution |
| Fraction of elite peers | -0.015*** | 7.2% | -0.010*** | 4.8% |
| | (0.002) | | (0.003) | |
| Student's middle school GPA | -0.050*** | 24.2% | -0.140*** | 67.6% |
| | (0.001) | | (0.005) | |
| Fraction of own elite parent | -0.116*** | 56.0% | 0.022*** | -10.6% |
| | (0.011) | | (0.003) | |
| *Mother's highest education level (ref = compulsory level)* | | | | |
| High school | -0.001*** | -0.5% | -0.003** | 1.4% |
| | (0.000) | | (0.001) | |
| University | -0.013*** | 6.3% | 0.007** | -3.4% |
| | (0.005) | | (0.003) | |
| *Father's highest education level (ref = compulsory level)* | | | | |
| High school | 0.000*** | 0.0% | 0.001 | -0.5% |
| | (0.000) | | (0.001) | |
| University | -0.038*** | 18.4% | 0.020*** | -9.7% |
| | (0.008) | | (0.006) | |

Notes: This table reports a selected set of results from the Oaxaca decomposition of the gap in elite degree enrolment between the high SES and low SES groups of students. Specifically, we estimate the equation 1 in the sample pooling both low and high SES children, denoted by $g = L, H$ respectively. See notes to Table 2 for description of the regression and controls. For each covariate $X_{ig}$ included in the model, we construct two objects, reported in the first and second columns of the table respectively. The first, $\Delta(X)$, measures the gap in elite education enrolment between High and Low SES students explained by the gap in average characteristic X between the two groups. That is: $\Delta(X) = \beta^p_X(E^H(X_i) - E^L(X_i)$ where $\beta^p_X$ is the coefficient associated with variable $X$ in equation 1 estimated in the pooled sample and $E^g(X_i), g = H, L$ is the expected value of $X$ in each sample. The second, $\Omega(X)$, measures the gap in elite education enrolment between High and Low SES students explained by the gap in the effect of characteristic X between the two groups. That is: $\Omega(X) = (\beta^H_X - \beta^L_X)E^p(X_i)$ where $\beta^g_X$ is the coefficient associated with variable $X$ in equation 1 estimated in the sample of students $g = H, L$. and $E^p(X_i)$ is the expected value of $X$ in the pooled sample.

**Table A5:** Placebo tests - Effect of elite peers on child birth outcomes

| | Point estimate | p-value | Number of students | Number of schools |
|---|---|---|---|---|
| Outcome variables: | | | | |
| Child birth weight | -3.303 | (0.584) | 169,864 | 554 |
| Low birth weight | 0.000 | (0.891) | 177,219 | 556 |
| Gestation | -0.027 | (0.584) | 157,669 | 552 |
| Height | -0.014 | (0.743) | 164,073 | 551 |
| Head circumference | 0.002 | (0.812) | 167,949 | 553 |
| Congenital malformation | -0.001 | (1.000) | 170,133 | 554 |
| Severe deformity | -0.002 | (0.5446) | 170,133 | 554 |

Notes: OLS estimates of the benchmark model (equation 1) on the full sample and where the dependent variables are predetermined characteristics of the student (indicated in the first column). Standard errors clustered at the school level and p-values adjusted using stepwise multiple hypothesis testing procedure that controls for family wise error rate. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

**Table A6:** Sensitivity analysis and interpretation

| | (1) Benchmark | (2) First born children | (3) Two-parent families | (4) Exclude Oslo | (5) Exclude small schools | (6) Control peer income & occupation |
|---|---|---|---|---|---|---|
| **A - Low SES students sample** | | | | | | |
| Proportion of parents with elite degree (std) | 0.013*** | 0.014*** | 0.013*** | 0.013*** | 0.013*** | 0.011*** |
| | (0.003) | (0.003) | (0.003) | (0.003) | (0.003) | (0.003) |
| *Number of pupils* | *58,610* | *51,270* | *49,025* | *52,938* | *50,882* | *58,610* |
| *Number of schools* | *524* | *524* | *518* | *482* | *280* | *524* |
| **B - High SES students sample** | | | | | | |
| Proportion of parents with elite degree (std) | 0.040*** | 0.041*** | 0.034*** | 0.040*** | 0.040*** | 0.042*** |
| | (0.008) | (0.008) | (0.008) | (0.009) | (0.008) | (0.009) |
| *Number of pupils* | *20,018* | *15,439* | *17,435* | *16,444* | *19,153* | *20,018* |
| *Number of schools* | *459* | *449* | *450* | *418* | *279* | *459* |

Notes: OLS estimates of the coefficient on the variable measuring the fraction of elite educated parents in the student's youth cohort in different specifications in the low SES sample (Panel A) and in the high SES sample (Panel B). Column (1) refers to the benchmark specification from (equation 1) and also reported in Table 2. Column (2) refers to the benchmark specification estimated just for first born children. Column (3) drops the sample of divorced or separated households. Column (4) refers to the benchmark specification this time estimated on the subsample of schools outside of Oslo. Column (5) refers to the benchmark specification excluding schools in the bottom decile of the size distribution. Column (6) refers to the benchmark specification where we also control for the fraction of peers whose parents are in the top decile of the income distribution and the fraction of peers whose parents work in high-paying/elite occupations. Standard errors clustered at the school level. *** p<0.01, ** p<0.05, * p<0.1

**Table A7:** Elite peer effect on GPA rank within the high school cohort

| | (1) Full sample | (2) Low SES | (3) High SES |
|---|---|---|---|
| **A - Overall GPA** | | | |
| | -8.270*** | -10.215*** | -5.744*** |
| | (0.433) | (0.543) | (0.463) |
| *Number of observations* | *177,219* | *58,610* | *20,018* |
| **B - Components of GPA** | | | |
| Externally assessed written exam grades | -6.140*** | -7.152*** | -4.670*** |
| | (0.349) | (0.434) | (0.475) |
| *Number of observations* | *177,219* | *58,610* | *20,018* |
| Teacher-assessed internal grades | -8.272*** | -10.141*** | -5.757*** |
| | (0.437) | (0.542) | (0.474) |
| *Number of observations* | *177,219* | *58,610* | *20,018* |
| Semi-externally assessed oral exam grades | -4.233*** | -5.941*** | -2.666*** |
| | (0.347) | (0.460) | (0.530) |
| *Number of observations* | *149,488* | *49,414* | *17,189* |

Notes: OLS estimates of the effect of the proportion of parents with an elite degree in the student's school's cohort in the benchmark model controlling for average peer ability where the dependent variable is now a measure of academic performance. See notes to Table 2 for detailed list of controls. The measures of academic performance are: overall high school GPA (row 1), average performance on externally assessed written exams across all three years of high school (row 2), average performance on teacher assessed grades across all three years of high school (row 3), and average performance on oral exams marked by an external examiner and the student's teachers across all three years of high school (row 4). All measures of performance are standardized to have mean 0 and standard deviation 1. 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. Standard errors clustered at the school level. *** p<0.01, ** p<0.05, * p<0.1

**Table A8:** Balance

| | (1) | (2) |
|---|---|---|
| | Low SES | High SES |
| Proportion of parents with elite degree (std) | -0.016* | -0.008 |
| | (0.008) | (0.008) |
| Student is female | 0.003 | -0.003 |
| | (0.005) | (0.007) |
| Student is born in Norway | 0.001 | 0.014 |
| | (0.007) | (0.010) |
| Mother years of schooling | -0.001 | 0.001 |
| | (0.001) | (0.001) |
| Father years of schooling | -0.001 | -0.001 |
| | (0.001) | (0.001) |
| Middle school teacher assessment | 0.068 | 0.036 |
| | (0.076) | (0.125) |
| Middle school written exams | 0.002 | 0.003 |
| | (0.007) | (0.012) |
| Middle school oral exams | 0.009 | -0.000 |
| | (0.006) | (0.010) |
| Middle school overall GPA | -0.132 | -0.082 |
| | (0.086) | (0.146) |
| Proportion of student's own parent with an elite degree | -0.032 | 0.007 |
| | (0.047) | (0.016) |
| Student's parents are in top income decile | -0.002 | -0.020** |
| | (0.008) | (0.008) |
| Number of pupils | 58,586 | 19,968 |
| Number of schools | 500 | 409 |
| *Number of pupils* | 51,512 | 17,559 |

Notes: OLS estimates of a regression of an indicator for a lottery into taking a maths examination in years 2 or 3 of high school on the set of covariates reported and additionally school, cohort and programme fixed effects. The low SES sample in column (1) 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 in column (2) 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