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Post-compulsory education and imprisonment☆

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HIGHLIGHTS

- We estimate the causal effect of post-secondary education on crime.
- The analysis uses Norwegian register data on education and imprisonment.
- The identification is based on constraints in the supply of school slots.
- We find a strong negative effect of high school education on imprisonment.
- This effect seems to be diminishing in the prior skills of the students.

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ABSTRACT

This paper studies the causal relationship between education and crime. Using Norwegian register data, we estimate the effect of a post-compulsory high school education on imprisonment for young adults. The identification in the instrumental variables model is based on variation in the supply of school slots across school districts and neighborhoods. We find that the number of semesters in high school education has a strong diminishing effect on imprisonment. The effect is robust to model specification, but seems to be related to prior skills.

1. Introduction

Crime has high social costs. The criminal justice system is costly, imprisonments have negative effects on labor force participation, and the pain for victims is significant for some types of crime. Becker (1968) and Ehrlich (1975) analyze crime in a utility maximization framework. The number of crimes committed by an individual is related to marginal costs (probability of conviction, punishment if convicted, etc.) and marginal utility (income from legal activity relative to illegal activity). Economic theory thus suggests that some policies can reduce crime by increasing the individual's net costs. An example is improved labor market performance, which increases the opportunity cost of committing a crime. Indeed, the recent empirical literature finds that the probability of criminal activity is related to labor market outcomes.[1] Because better educational performance improves human capital and thus labor market outcomes, theory suggests a causal negative effect of education on crime.[2]

A large literature has investigated the relationship between years of education and crime. Recent papers have exploited variation in years of compulsory schooling to identify a causal relationship (Lochner and Moretti, 2004; Anderson, 2010; Machin et al., 2011; Meghir et al., 2011; Hjalmarsson et al., 2011). These studies typically find a causal effect that is similar to or larger than descriptive differences, which indicates that unobserved heterogeneity does not bias simple relationships downwards. The external validity of these studies must, however, be interpreted with care. The contents of the

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[1] See for example Grogger (1998), Machin and Meghir (2004), Lin (2008), and Fougère et al. (2009).

[2] As discussed by Lochner and Moretti (2004) and Machin et al. (2012), education might decrease criminal activity also by other mechanisms. Education can possibly increase risk aversion, influence preferences, and raise the stigma related to criminal activity. In addition, time spent in education might have a "self-incapacitation" effect.

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reforms are to various extents unclear, in particular with regard to school quality, and they were implemented more than 40 years ago. [3]

We estimate a causal effect of post-compulsory schooling on imprisonment using recent Norwegian data. Post-compulsory education is a choice variable and less studied in causal frameworks. Machin et al. (2012) study a large expansion of post-compulsory education in the UK around 1990, and identify the effect of education by cohort indicators. Related evidence is based on a UK policy intervention introducing bonuses to 16–18 year olds from poor families on completion of coursework. The intervention seems to have improved the rate of students staying in school (Dearden et al., 2009) and reduced crime (Sabates and Feinstein, 2008).

Our IV analysis uses two measures of supply of school slots as instruments for post-compulsory high school education. Compulsory education in Norway is without grade repetition and tracking. Post-compulsory high school education consists of either three-year long academic study tracks or four-year long vocational study tracks. Most of the individuals stay several semesters in high school education, but only about 2/3 of the cohort graduates within five years. School structure and the supply of study places at different study tracks are county decisions. Since vocational study tracks require more semesters than academic study tracks, we expect the number of semesters in high school, at the individual level, to be positively related to the share of vocational study places in the county. This instrument has predictive power in spite of the fact that weaker students enroll in vocational study tracks. The second instrument is geographical proximity to high schools.

The skills inherent in human capital are multifaceted and related to factors such as school quality,[4] home environment, and innate ability, in addition to years of education. Compared to the previous literature, our data include an extensive set of socioeconomic characteristics and indicators for schools and neighborhoods. Heckman et al. (2006) and Carneiro et al. (2007) find that both cognitive and non-cognitive skills reduce self-reported crime. The estimated effect of years of schooling might therefore be related to skills. Consequently, we include GPA from compulsory education in the empirical model and investigate whether the effect of education on crime depends on GPA.

The paper is organized as follows. The next section presents relevant institutional information and data descriptions. Section 3 discusses the empirical approach, while the results are presented in Section 4. We show that the local average treatment effect of years of post-compulsory high school education on imprisonment is larger than the OLS estimate, but there appears to be important heterogeneities. Section 5 concludes.

2. Institutions

2.1. School system

Norwegian compulsory education consists of 10 years.[5] It is not possible to fail a class; grade repetition is non-existent.[6] Everybody graduates from compulsory education at the end of 10th grade, and receive a diploma containing 13 different grades set by teachers and the result on a written external exit exam in either Norwegian, or English, or mathematics. The grade system consists of a scale from one to six, where one is the lowest and six is the highest grade.[7] The average grade from compulsory education (GPA) matters for the non-compulsory high school enrolment.

The municipalities are responsible for compulsory education, while the counties are responsible for post-compulsory high school education. For the 19 counties in Norway, the most important task is to provide high school education, which accounts for over 50% of total county spending. About 95% of each cohort enrolls in high school directly after the end of compulsory education. The counties are financed by grants from the central government.

When starting high school, the students could choose between 15 different study tracks in the empirical period of this paper. The main distinction is between academic study tracks and vocational study tracks. The latter includes industrial design, health and social work, mechanics, electrical trades, etc., and typically consists of two years of schooling followed by two years as an apprentice. An academic study track consists of three years of schooling and leads to a high school diploma, which is required for university enrollment.

All students have a legal right to complete high school, but it has to be within a time frame of five years. There is an option for the student to apply for a transfer to another study track or school. However, transfer to another study track most often implies grade repetition and a longer time period before graduating. In their application for high school enrollment, students have to rank three different study tracks. They have a legal right to be enrolled in one of these three tracks, but whether they are enrolled in the first, second, or third preferred track depends on their GPA. Enrollment in different study tracks and schools is thus decided by student demand and the supply of study places provided by the county. The counties decide the location of schools, the composition of different study tracks at each school, the degree of school choice, and the spending level at each school and study track.

2.2. Judicial system

The Norwegian constitution is founded on the principle of "separation of powers", formulated by the French philosopher Montesquieu, and the principle of popular sovereignty. This ensures that the judicial functions are well separated from the legislative and the executive powers. The main courts of justice are divided into three levels. They consist of the District Courts in the first instance, the Courts of Appeal in the second instance, and the Supreme Court in the third instance. Norway is divided into 66 judicial districts, with one District Court per judicial district. The judicial districts include 1–19 municipalities.

The police districts are larger than the judicial districts. During an investigation, the police may hold a suspect in custody for three days without a court order. Beyond this time, the police needs approval from the District Court in order to keep the suspect in custody. Custody is only used when the freedom of the suspect is believed to interfere with the investigation. For most offenders, the investigation period does not include any days spent in custody. When the investigation is finished, the case is brought before the District Court by the prosecution authorities.

Thus, there is typically a time lag from when a crime is committed to imprisonment, except for custody. There is not much data available on the length of this period, but for crimes committed in 1997 and taken to court, the average number of days before the trial was 153. As far as we know, there is no major trend in this regard over the

[3] While Machin et al. (2011) estimate a strong effect of education on crime when exploiting the British school leaving age reform in 1972, Clark and Royer (2010) find little evidence that additional education improves health outcomes or changes health behavior when they exploit the British school leaving age reforms in 1947 and 1972.

[4] Some other papers have investigated the effect of school quality. Cullen et al. (2006) and Deming (2011) exploit school admission policies based on lotteries. The winners of the lotteries are considered to have attended schools of higher quality than the losers. Both papers find that lottery winners commit less crime.

[5] The school system is relatively homogenous. Less than two percent of all students attend a private compulsory school. Private compulsory schools are mainly Christian schools or schools with an alternative pedagogical approach. Private high schools enroll about 5% of the students. Both private compulsory schools and private high schools receive grants per student from the central government. The grant typically amounts to 85% of average spending per student in public schools. The condition for the grant is that the school only charges tuition of up to 15% of average spending per student in public schools.

[6] This indicates that students are supposed to be of the same age at the end of compulsory education. However, there are some exceptions. It is possible to start one year ahead of the birth cohort, and the student may postpone starting school for one year if not considered mature enough. These decisions are made by the parents together with the school and psychologists. In addition, some older students return to school to improve their grades, and immigrants are often over-aged.

[7] All individuals graduate from compulsory education by law, and it is in principle not possible to fail a subject. However, in some cases teachers do not have the necessary information to set a grade, and students might be exempted from specific subjects. In particular, about 10% of the students do not have a grade in the second official written Norwegian language.

Table 1
Imprisonment at age 22 (the period from June 16 to June 15) and high school attainment.

	All		Less than 3 years in high school		At least 3 years in high school		Graduated from high school	
	Imprisonment	Observations	Imprisonment	Observations	Imprisonment	Observations	Imprisonment	Observations
Percent in prison at least once ('All imprisonment')								
All	0.76	159,799	3.17	15,401	0.50	144,398	0.19	11,138
Male	1.37	81,641	5.16	8590	0.92	73,051	0.36	52,992
Female	0.13	78,158	0.66	6811	0.08	71,347	0.03	58,146
Number of days in prison ('Days in prison')								
All	0.54	159,799	2.70	15,401	0.31	144,398	0.08	111,138
Male	0.98	81,641	4.48	8590	0.57	73,051	0.15	52,992
Female	0.07	78,158	0.49	6811	0.03	71,347	0.02	58,146
Percent in custody at least once ('Custody imprisonment')								
All	0.14	159,799	0.73	15,401	0.07	144,398	0.02	111,138
Male	0.25	81,641	1.26	8590	0.14	73,051	0.03	52,992
Female	0.02	78,158	0.07	6811	0.01	71,347	0.01	58,146

last 10–20 years. Most cases are finalized in the District Court. Statistics regarding the time period from trial in the District Court to imprisonment do not seem available, but casual evidence indicates that the typical period is a few months. Young people are prioritized and should experience shorter waiting periods.

2.3. Data and descriptive statistics

The student data is obtained from the National Educational Database of Statistics Norway, and consist of all students finishing compulsory education during the years 2002–2004. The student information is matched with information about their parents, school identifiers, and a neighborhood identifier for the year the individual finished compulsory education.

Information on incarceration is provided by the Norwegian Correctional Services. The data include the date of imprisonment, the date of release, and an indicator variable for custody incarceration. Our dependent variables are related to the year starting six years after the completion of compulsory education and includes a binary variable equal to one if the individual has been incarcerated at least one day ('All imprisonment'), the number of days in prison ('Days in prison'), and a binary variable for custody ('Custody imprisonment'). The start and the end of the period is June 16 the year the individuals turn 22 and June 15 the year they turn 23, respectively.

Compared to the variable 'All imprisonment', the variable 'Days in prison' takes the severity of the crime into account. 'Custody imprisonment' is not used for minor crimes, which implies that also this variable reflects more severe crime. In addition, custody normally occurs right after the act of crime and might therefore better control for the age at which the crime is committed.

Appendix Table A1 presents descriptive statistics for the Norwegian population of graduates from compulsory education during the years 2002–2004. The three cohorts consist of 174,067 individuals. On average, 0.81% has been in prison at least once in the relevant one-year period. The average number of days in prison in this period is 0.60, which implies that incarceration lasted 75 days on average. About 2/3 of the cohort graduated from high school within the legal framework of five years. On average, the individuals have been 6.55 semesters (3.28 years) in high school. This is the average over those graduating and those not graduating. When splitting the sample, these two groups spent on average 6.94 and 5.78 semesters in high school, respectively (not reported in the table).

Appendix Table A1 also presents descriptive statistics for the control variables in the analysis. Benefits due to disabilities or disease before the age of 18 are received by 2.5%, while 3.4% have received benefits to support needs for private nursing or care. The other variables are measured the year the individuals graduate from compulsory education. At that time, 18% of the individuals had parents with compulsory education only, while 45% had at least one parent with a high school degree as their highest level of education. For 67% of the individuals, both parents are employed, while for 24% either the father or the mother is employed. 58.1% of the individuals have married parents and 12.3% have divorced parents. Skills, as measured by GPA at the end of compulsory education, have an average value of 3.95 and standard deviation of 0.83.

We restrict the regression sample to normal-aged individuals. In addition, there are some missing observations, in particular for GPA and the neighborhood identifier.[8] The regression sample consists of 91.8% of the population. As shown in Appendix Table A1, average imprisonment is slightly lower in the regression sample compared to the population, while high school attainment and parental education are slightly higher. This is related to the fact that the share of first generation immigrants is halved in the regression sample because they tend to be over-aged when finishing compulsory education.

Table 1 presents summary statistics on the relationship between imprisonment at age 22 and high school attainment in the regression sample. The table shows that imprisonment is related to number of years in high school education. 3.17% of the individuals with less than three years in high school were in prison in the relevant one-year period, compared to 0.50% of the individuals with at least three years in high school. Fig. 1 presents the relationship between the imprisonment rate and number of semesters in high school in more detail. Imprisonment is clearly more common for individuals that dropped out after just a few semesters in high school. Those with six semesters or more in high school have a low probability of incarceration at age 22. In addition, it follows from Table 1 that custody is 10 times more likely for individuals with the least amount of high school education, and that those incarcerated, spent, on average, the longest time spells in prison. These patterns are similar for women and men although imprisonment in general is much higher for men than for women. On average, only 0.13% of women were in prison in the relevant time period, compared to 1.37% of men.

Table 1 clearly indicates that the relevant dimension for the crime–education relationship is high school attainment. For individuals who have graduated from high school, imprisonment is only 0.2%. Educational decisions regarding higher education cannot be important for crime measured by the likelihood of imprisonment. This pattern is even stronger for the number of days in prison and the likelihood of custody. The number of days in prison, given imprisonment, is 42 for high school graduates and 75 for dropouts (not shown in table). Thus, the severity of the crime committed seems to be higher for dropouts.

The descriptive evidence in Table 1 indicates that there is a positive effect of just staying in school. It is not simply the high school degree that matters, but also years of education. This finding motivates our focus on the effect of the number of completed semesters in the empirical analysis below. Fig. 2 presents average imprisonment rates at different ages for the regression sample.[9] The figure follows

[8] We regard GPA as missing if the student has a grade in less than four out of the 13 subjects, which excludes 4.9% of the population from the regression sample.

[9] Imprisonment at age 16 is measured during the one-year period starting at the end of compulsory education.

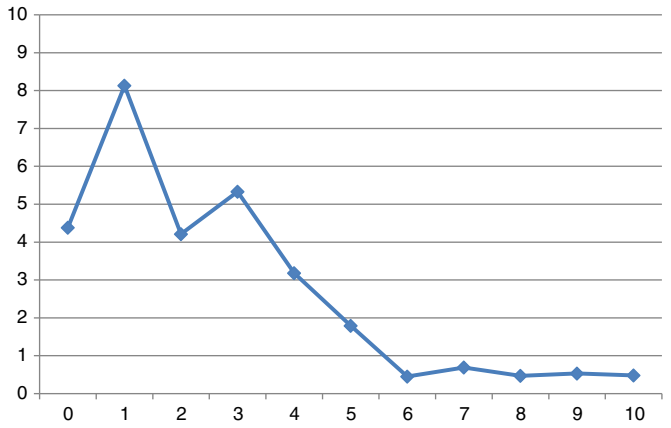

Fig. 1. Imprisonment for different numbers of completed semesters, percent.

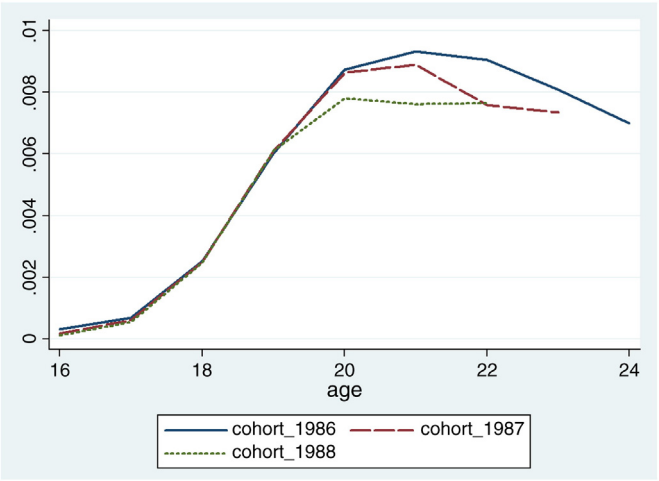

Fig. 2. Average imprisonment rate at different ages.

the oldest cohort (born in 1986 and finishing compulsory education in 2002) to the age of 24 and the youngest cohort to the age of 22 (6–7 years after the completion of compulsory education). Before the age of 18, very few have been in prison, while the proportion of the individuals in prison peaks at ages 20–22 at 0.8–0.9%. The imprisonment rate at age 22, which is our dependent variable, is still high.

High school attainment is clearly related to skills. Thus, in order to identify the effect of high school education, it might be important to condition on prior skills. Fig. 3 presents the distribution of GPA related to imprisonment at the age of 22. The figure shows that the distribution of GPA is skewed to the left for individuals incarcerated.

3. Empirical approach

Consider the following relationship between number of semesters in high school (HS) and imprisonment (Y):

$$Y_i = \beta_0 + \beta_1 HS_i + X_i\beta_2 + \varepsilon_i \quad (1)$$

where X_i is a vector of socioeconomic characteristics for individual i and ε_i is the i.i.d. error term. In our analysis, X includes gender, immigration status, parental education, parental income, parental labor market status, parental marital status, month of birth, and public benefits before age 18 related to disabilities. In addition, the model includes the number of students at the compulsory school the student graduated from and cohort specific effects.

There are several reasons why an ordinary least square estimate of β_1 cannot be regarded as a causal effect. First, the underlying reason why compulsory school reforms reduce crime could be increased skills of the students. Skills, in turn, might reduce crime directly or via a positive effect on post-compulsory education. Indeed, Falch and Strøm (2013) show that GPA from compulsory education is strongly related to high school attainment in Norway.[10] Prior achievement is not included in previous studies of the relationship between crime and education. To address this issue, we investigate whether the effect of high school attainment is robust to the inclusion of GPA from compulsory education as a control variable. Second, even though our model includes a rich set of individual and family characteristics, there may still be unobserved determinants of imprisonment that are correlated with years of schooling. Thus, we include different sets of fixed effects interacted with cohort dummy variables as additional controls. Court fixed effects take into account possible different behaviors in the District Courts, compulsory and high school fixed effects control for unobserved school quality, and we also estimate a model with neighborhood fixed effects based on residence (at the 'ward' level) on January 1 in the last year of compulsory education.[11]

The fixed effects models can hardly account for omitted variables at the individual level. As a result, we exploit that school structure is a county decision in an instrumental variable analysis. The instruments capture different aspects of the school structure and are measured at different aggregation levels.

The share of a cohort enrolling in vocational study tracks is determined by county policies, and we lag the variable one year in order not to count on the students in the relevant cohort.[12] Vocational study tracks typically involve more semesters than academic study tracks. Hence, we expect the number of semesters in high school, at the individual level, to be positively related to the share of vocational study places in the county. The selection of students into the different study tracks is based on individual preferences and their GPA from compulsory education. This selection works in the opposite direction since those enrolling in vocational study tracks are on average of lower socioeconomic status than those who start an academic career. For example, 55 and 25% of the students that enroll in academic and vocational study tracks, respectively, have at least one parent with a college degree. Likewise, GPA from compulsory education is about one standard deviation lower for the latter group. A positive effect of the share of vocational study tracks on number of semesters in high school is therefore not a result of high skill students sorted into longer education.

Fig. 4 illustrates the identification. The figure plots the average number of semesters against the share of students enrolled in vocational study tracks at the county level, and includes the official county identifier. Both variables are measured conditional on the control variables in the model. Clearly, a higher share of students enrolling in vocational study tracks implies more semesters in high school education on average.

The second instrument utilizes information on geographical proximity to high schools as developed by Falch et al. (2013). They find that geographical proximity increases the probability of graduating from high school on-time. We expect high school education to be more cumbersome when there are few high schools within commuting distance, increasing the number of semesters in high school. The exclusion restriction is that school structure, decided by the county council, does not directly influence criminal behavior. In addition,

[10] Using the data in the present paper, we find for models conditioning on the same individual characteristics as in our baseline model that one standard deviation of GPA increases the number of semesters in high school education by 0.13 and the probability of high school graduation within five years by 23.7 percentage points.

[11] The data include 66 District Courts, 1200 compulsory schools, 484 high schools, and 12,585 wards. The schools are homogeneous in terms of curriculum and instruction time. Individuals who did not enroll in high school education the year they finished compulsory education are provided a separate high school indicator.

[12] Using the vocational share for the current cohort instead of the lagged cohort as the instrument gives the same qualitative results as reported below.

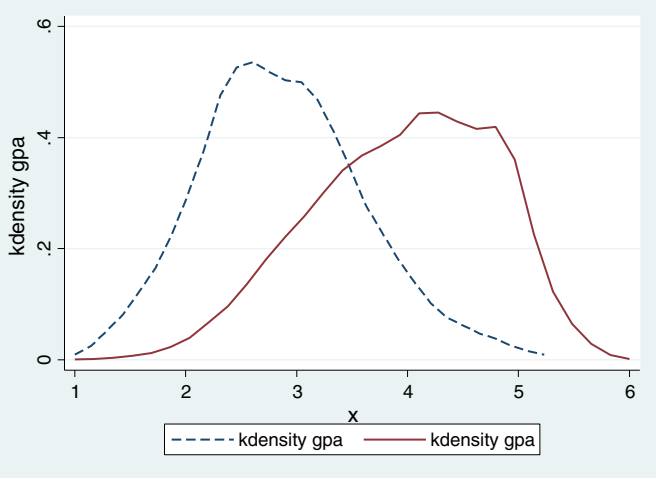

Fig. 3. Imprisonment and GPA.

families' residential decisions are not related to expectations of their children's future criminal behavior.

Residence is registered at the ward level on January 1 the last year of compulsory education. Norway is divided into about 14,000 wards, which gives a reasonably precise localization of residence. A ward belongs to one specific compulsory school catchment area and consists on average of about 5 students in each cohort. ArcGIS Network Analyst is used to determine the midpoint of the ward's populated area and to calculate travel time on public roads between students' home ward midpoint and high schools, taking speed limits into account. We use the distances as calculated on the school structure in 2002 for all cohorts. The instrument is a dummy variable for whether there are no more than three high schools within 30 minutes driving time. Appendix Table A1 shows that 27% of the sample has at most three high schools within commuting distance.

Parents can in principle react on weak supply of school slots by moving to other areas. While we have detailed information on residence the last year in compulsory education, residence thereafter is unknown. Thus, we are unable to analyze this question directly, but we explore this issue in different ways in the analysis below. First, we have information about school district at school starting age and at age 13. At age 13 the students start lower secondary education, and these schools are typically larger than the primary schools. We will investigate whether the results are robust to excluding "mobile" students defined as observed mobility during compulsory education. Second, if there is strategically mobility, it would arguably be related to socioeconomic characteristics. Thus, we investigate whether the results are robust to excluding all socioeconomic characteristics from the model. Finally, the instrument measured at the county level should be little vulnerable to endogenous sorting because it would require long-distance moves.

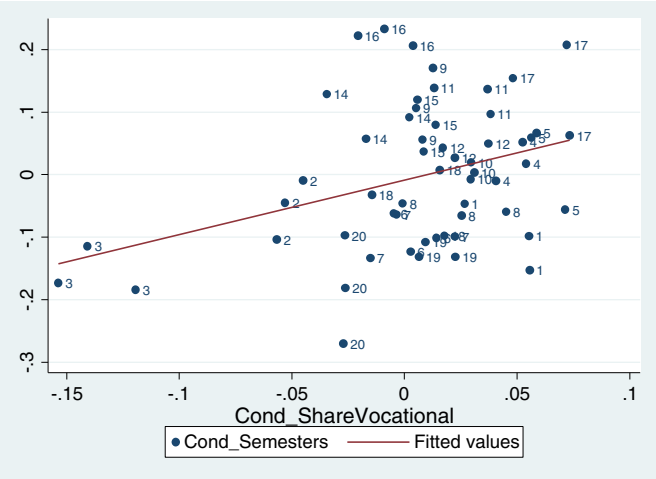

Fig. 4. Number of semesters in high school and study track composition at the county level.

The variation in high school education induced by the instruments is arguably negligible for individuals at the top of the education distribution. The effect we estimate is a local average treatment effect among the individuals that react to the school structure as measured by our instruments.

One alternative identification approach is to use school openings and closures in a difference-in-differences framework. Unfortunately, high school attainment has been relatively stable in Norway the last 2–3 decades. High school education expanded during the 1970s and 1980s, but since around 1990 the enrollment and graduation rates have been stable at about 95 and 70%, respectively. In addition, there have been relatively small fluctuations in cohort size.[13] Consequently, the school structure has been stable. While this makes it impossible to use a difference-in-differences approach in this paper, it also implies that the school structure is not determined by the preferences of the students in the present sample.

We perform robustness analyses, and investigate whether the effect of interest depends on gender, parental education, and GPA from compulsory education. Regarding GPA, the hypothesis is that high school education and prior skills are substitutes in crime behavior. Both these measures of educational performance are positively related to human capital and are expected to increase the net costs of criminal activity.

4. Results

4.1. OLS and fixed effects models

Table 2 presents results for various ordinary least square model specifications using the dummy variable for all imprisonment (panel A), the number of days in prison (panel B), and the dummy variable for custody (panel C) as dependent variables. Since the question of imprisonment is a decision of the District Courts, the standard errors are clustered at the District Court level.

The model specification in column (1) only includes the number of semesters in high school education. In all three panels education is associated with lower incarceration. One additional semester in high school (0.65 standard deviation) is associated with 0.37 percentage points lower probability of imprisonment during the one-year period at the age of 22, 0.36 fewer days in prison, and 0.10% age points smaller probability of custody. These associations are highly significant in both statistical and economic terms. In terms of mean values of the dependent variables, the effects are 50–70%.

Column (2) in Table 2 includes socioeconomic characteristics and cohort specific effects, which only slightly reduces the associations. Column (3) additionally includes prior student achievement measured by GPA from compulsory education. GPA is strongly related to high school education, but again the associations of interest are only slightly reduced. GPA itself, however, is strongly associated with incarceration. One standard deviation higher GPA (0.83 grade points) is associated with 0.93% age points lower probability of imprisonment, which is 103% of the mean value.

Columns (4)–(7) in Table 2 provide fixed effects specifications. Because there might be differences in punishment practices across the District Courts, the first model includes court by cohort fixed effects. The model in column (5) includes compulsory school by cohort fixed effects, and the model in column (6) includes, in addition, high school by cohort fixed effects. Finally, column (7) includes 32,701 neighborhoods by cohort fixed effects.[14]

[13] During the 1990s, the number of students finishing compulsory education was in the range 51,000 to 52,000. The cohort size started to grow after the turn of the century, and exceeded 60,000 in 2005. This growth has mainly been absorbed by expanding existing schools and not by establishing new schools.

[14] The district court fixed effects are saturated by the compulsory school fixed effects, and the compulsory school fixed effects are saturated by the neighborhood fixed effects.

Table 2
The relationship between high school education and imprisonment.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A dependent variable is 'All imprisonment'								
Number of semesters in high school	−0.0037***	−0.0034***	−0.0031***	−0.0030***	−0.0029***	−0.0027***	−0.0027***	−0.0024***
	(0.0003)	(0.0003)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
GPA	–	–	−0.0093***	−0.0094***	−0.0094***	−0.0091***	−0.0094***	−0.0076***
			(0.0005)	(0.0005)	(0.0005)	(0.0006)	(0.0006)	(0.000562)
Graduated from high school	–	–	–	–	–	–	–	−0.0064***
								(0.0009)
Panel B dependent variable is 'Days in prison'								
Number of semesters in high school	−0.355***	−0.328***	−0.305***	−0.304***	−0.289***	−0.268***	−0.278***	−0.253***
	(0.033)	(0.032)	(0.031)	(0.031)	(0.030)	(0.028)	(0.029)	(0.029)
GPA	–	–	−0.665***	−0.666***	−0.657***	−0.631***	−0.678***	−0.530***
			(0.058)	(0.059)	(0.055)	(0.059)	(0.068)	(0.068)
Graduated from high school	–	–	–	–	–	–	–	−0.526***
								(0.091)
Panel C dependent variable is 'Custody imprisonment'								
Number of semesters in high school	−0.0010***	−0.0009***	−0.0009***	−0.0009***	−0.0008***	−0.0008***	−0.0008***	−0.0007***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
GPA	–	–	−0.0017***	−0.00169***	−0.00164***	−0.00151***	−0.00160***	−0.0012***
			(0.0003)	(0.0003)	(0.0002)	(0.0003)	(0.0003)	(0.0003)
Graduated from high school	–	–	–	–	–	–	–	−0.0014***
								(0.0003)
Socioeconomic characteristics	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District Court ∗ cohort fixed effects	No	No	No	Yes	–	–	–	–
Compulsory school ∗ cohort fixed effects	No	No	No	No	Yes	Yes	–	–
High school ∗ cohort fixed effects	No	No	No	No	No	Yes	Yes	Yes
Neighborhood ∗ cohort fixed effects	No	No	No	No	No	No	Yes	Yes
Observations	159,799	159,799	159,799	159,799	159,799	159,799	159,666	159,666

Note: The socioeconomic characteristics included are reported in Appendix Table A1. Standard errors clustered at the District Court level are reported in parentheses.
*** Denotes significance at the 1% level.

The coefficients of interest are stable across these fixed effects models. Overall, the effect of high school attainment is not very sensitive to the inclusion of potential compound factors. In the most flexible model specification (column (7)), the effect of one additional semester in high school is in the range 0.35–0.54% of the average value of the dependent variable.

The last column in Table 2 includes a dummy variable for high school graduation. While the associations with graduation are highly significant, the effect of the number of semesters in high school is hardly affected by this change in model specification. This finding reassures the finding in Table 1 that just staying more years in high school is associated with lower imprisonment.

4.2. Main results

Even though the estimates above are not particularly sensitive to the inclusion of an extensive set of control variables and fixed effects, they cannot readily be interpreted as causal effects. We use two measures of the supply of school slots as instruments for the number of semesters in high school; the lagged share of vocational study places in the county and a dummy variable for few schools within commuting distance. The results are presented in Table 3. Standard errors are clustered by county because study track composition is measured at the county level.

In the reduced form models in columns (1)–(3), both the share of students enrolled in vocational study tracks and scarcity of high schools within commuting distance are negatively related to imprisonment. The effects of few schools nearby on number of days in prison and custody imprisonment are relatively large. In the first stage regression, the share of students enrolled in vocational study tracks is significant at the one percent level, while the distance-variable is significant at the five percent level. The first stage indicates that increasing the share of study places in vocational study tracks by 10 percentage points increases the number of semesters in high school

Table 3
The causal effect of high school education on imprisonment.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Reduced form			First stage	Second stage		
	All imprisonment	Days in prison	Custody imprisonment	Semesters in high school	All imprisonment	Days in prison	Custody imprisonment
Number of semesters in high school	–	–	–	–	−0.0072**	−1.124**	−0.0048***
					(0.0035)	(0.437)	(0.0018)
Share of students in vocational study tracks at the county level, lagged one year	−0.0042	−0.069	−0.0020*	0.842***	–	–	–
	(0.0039)	(0.273)	(0.0010)	(0.223)			
At most 3 high schools within 30 minutes travel time from the student's residence	−0.0009	−0.234***	−0.0007***	0.076**	–	–	–
	(0.0005)	(0.051)	(0.0002)	(0.027)			
F-test for instruments	–	–	–	16.3	–	–	–
Test of overidentifying restrictions, p-value	–	–	–	–	0.401	0.008	0.054

Note: The model specifications are similar to the model specifications in column (3) in Table 2, except as indicated. Full results for the models in columns (4)–(7) are reported in Appendix Table A2. Standard errors clustered at the county level are reported in parentheses.
* Denotes significance at the 10% level.
** Denotes significance at the 5% level.
*** Denotes significance at the 1% level.

Table 4
Robustness analyses.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Age at which the dependent variables are measured	Age 22	Age 22	Age 22	Age 22	Age 22	Age 22	Age 21–22
Panel A dependent variable is 'All imprisonment'							
Number of semesters in high school	−0.0072**	−0.0058	−0.0068*	−0.0055	−0.0103*	−0.0083**	−0.0087*
	(0.0035)	(0.0038)	(0.0035)	(0.0042)	(0.0062)	(0.0041)	(0.0051)
Panel B dependent variable is 'Days in prison'							
Number of semesters in high school	−1.124**	−1.103**	−1.090***	−0.353	−2.582***	−0.976**	−1.765***
	(0.437)	(0.531)	(0.266)	(0.312)	(0.783)	(0.452)	(0.609)
Panel C dependent variable is 'Custody imprisonment'							
Number of semesters in high school	−0.0048***	−0.0048**	−0.0057***	−0.0030**	−0.0082***	−0.0048***	−0.0094***
	(0.0018)	(0.0020)	(0.0008)	(0.0014)	(0.0023)	(0.0016)	(0.0012)
F-test for instrument(s)	16.3	16.9	17.0	16.7	13.7	14.2	16.3
GPA included	Yes	No	No	Yes	Yes	Yes	Yes
Socioeconomic characteristics included	Yes	Yes	No	Yes	Yes	Yes	Yes
Share of students in vocational study tracks at the county level used as instrument	Yes	Yes	Yes	Yes	No	Yes	Yes
At most 3 high schools within 30 minutes travel time from the student's residence used as instrument	Yes	Yes	Yes	No	Yes	Yes	Yes
Sample	All	All	All	All	All	Non-movers	All
Observations	159,799	159,799	159,799	159,799	159,799	140,396	159,799

Note: The model specifications are similar to the model specifications in Table 3, except as indicated. Standard errors clustered at the county level (District Court level in column 4) are reported in parentheses.
* Denotes significance at the 10% level.
** Denotes significance at the 5% level.
*** Denotes significance at the 1% level.

education by about 0.08. This effect is of about the same size as having few high schools within commuting distance. The F-value of joint significance of the excluded instruments is 16.3.[15]

Columns (4)–(6) in Table 3 present the causal effects of education.[16] The effects of number of semesters in high school are significant at the five percent level for all three measures of imprisonment, and much larger than the OLS-estimates. Staying one additional semester in high school decreases the probability of imprisonment by 0.72 percentage points, the probability of custody imprisonment by 0.48 percentage points, and the number of days in prison by slightly over one day.[17] The causal effect on the indicator for all imprisonment is almost 2.5 times larger than the OLS estimate, while for days in prison, which take the severity of the crime into account, the causal effect is about 4 times larger than the OLS estimate. Regarding custody imprisonment, which arguably reflects the most severe crimes committed, the causal effect is over five times larger.

These differences between the causal effects and the OLS estimates are of the same magnitude as found by Machin et al. (2012) for post-compulsory education in the UK.[18] The effects can also be interpreted in percentage terms. Compared to mean values, the causal effects of one year of high school education (i.e., two semesters of high school education) are 1.9%, 4.2%, and 6.9% for 'All imprisonment', 'Days in prison', and 'Custody imprisonment', respectively. The size of the first of these effects is in line with the findings for convictions in Machin et al. (2012). Interestingly, not only does the difference between the OLS estimate and the causal effect increase as the dependent variable reflects more and more severe crime, but also does the causal effect in percentage terms.

4.3. Robustness analyses

Table 4 presents robustness analyses in terms of control variables, the instruments, the sample, and the dependent variables. The first column replicates the model in Table 3 for convenience. The models in column (2) exclude GPA. As for the OLS model, the inclusion of GPA hardly affects the estimates. However, for the variable 'All imprisonment' the effect of high school education drops by 20% and becomes insignificant. The model in column (3) excludes, in addition, all the socioeconomic characteristics. Again the effects are in line with the main results.

Columns (4) and (5) in Table 4 present results for models including only one of the instruments. Only the share of students in vocational study tracks, lagged one year, is used as instrument in column (4) and only the indicator for few schools within commuting distance is used as instrument in column (5). The local average treatment effect (LATE) is lower in the former case than in the latter case. Compared to the baseline model in column (1), the effect of high school education on 'All imprisonment' is about 20% lower in the former case and about 40% higher in the latter case. The difference between the LATEs is particularly pronounced for 'Days in prison', and in column (4) the effect of education is significant at conventional levels only for 'Custody imprisonment'. None of the model formulations seems to be plagued by a weak instrument since the F-value of significance of the excluded instrument in the first stage is above 10 in both cases.

The findings so far indicate that the estimated effects of post-compulsory education are not driven by endogenous mobility of parents. The effects are robust to the handling of the control variables, and they are qualitatively similar in the model using only variation across counties for identification. Column (6) in Table 4 provides further evidence. This model excludes individuals that are observed moving across municipalities (compulsory school districts) during compulsory education, which are arguably the most mobile families. In this model the sample is reduced by 12.1%, but the estimated effects of post-compulsory education hardly change.[19]

[15] We have also tested whether these instruments are correlated with graduation from high school. However, the F-value of joint significance in this case is only 0.9.
[16] Full estimation results of the first and second stage models are presented in Appendix Table A2.
[17] Table 3 presents results for an overidentification test of the instruments. The test does not reject the validity of the instruments at five percent level in the models for 'All imprisonment' and 'Custody imprisonment', but it rejects for 'Days in prison'.
[18] Machin et al. (2011) also find a larger causal effect than the OLS estimate for their educational variable 'No qualifications'.
[19] 9.4% of the individuals lived in different municipalities at the start and the end of primary education, while 4.1% of the individuals lived in different municipalities at the end of primary education (age 13) and the end of compulsory education (age 16). 1.4% of the individuals belong to both these groups.

Table 5
Heterogeneous effects of high school education on imprisonment.

	(1)	(2)	(3)	(4)	(5)	(6)
Sample	Boys	Girls	Low educated parents	High educated parents	GPA below median	GPA above median
Panel A. Dependent variable 'All imprisonment'						
Number of semesters in high school	−0.0121***	−0.0025	−0.0177***	0.00112	−0.0151**	0.0006
	(0.0050)	(0.0034)	(0.0063)	(0.0039)	(0.0060)	(0.0021)
Effect of one year of education in percent	−177	−384.6	−351	62	−212	132
Panel B. Dependent variable 'Days in prison'						
Number of semesters in high school	−1.756***	−0.237	−2.284***	−0.279	−1.848***	−0.095
	(0.492)	(0.0307)	(0.848)	(0.276)	(0.667)	(0.096)
Effect of one year of education in percent	−357	−677	−634	−223	−364	−368
Panel C. Dependent variable 'Custody imprisonment'						
Number of semesters in high school	−0.0075***	−0.0006	−0.0109***	0.0005	−0.0068**	−0.0017***
	(0.0025)	(0.0006)	(0.0037)	(0.0008)	(0.0028)	(0.0006)
Effect of one year of education in percent	−599	−600	−589	173	−540	−1790
F-test for instruments	22.5	7.9	8.7	48.8	11.1	19.7
Observations	81,641	78,158	97,947	61,852	80,584	79,215

Note: The model specifications are similar to the model specifications in Table 3, except as indicated. Standard errors clustered at the county level are reported in parentheses.
** Denotes significance at the 5% level.
*** Denotes significance at the 1% level.

In the last column in Table 4, the dependent variables are extended to cover imprisonment in a two-year period starting five years after the completion of compulsory education, i.e., in June the year the individual turn 21. In this case there is more information in the imprisonment variables since more people have been incarcerated, and for longer periods.[20] Including imprisonment at age 21 only marginally affects the estimates, except for 'Days in prison' as expected, since the sample range of this variable has increased.

4.4. Heterogeneity

Finally, we investigate whether the effect of high school attainment depends on gender, parental education, and GPA. Table 5 presents results for models that split the sample according to these variables.

The coefficients of high school education are larger for boys than for girls and insignificant at conventional levels for girls. The incidence of imprisonment is, however, much lower for girls than for boys. The table shows that the effect of two more semesters in high school in percent of the mean value of the dependent variable is, in fact, larger for girls than for boys. Thus, these results cannot in general be interpreted as high school education has a larger negative effect on imprisonment for boys than for girls because our data seem limited in order to estimate reasonable models for girls.

Columns (3) and (4) in Table 5 split the sample according to parental education. When none of the parents has higher education (61% of the sample), the effect of high school education on imprisonment is large, while when at least one of the parents has a college degree, the effect is small and insignificant. The effects in percentage terms are also lower in the latter case, which indicates that the crime reducing effect of education is mainly related to individuals with low-educated parents.

The last part of Table 5 distinguishes between students with GPA below and above the median value. The crime reducing effect seems to be concentrated to low-achieving students.[21] Even though the estimated effect of high school education does not seem to be sensitive to whether GPA is included in the model or not (Tables 2 and 4), it seems to depend on the GPA level.

Since GPA is a continuous variable, in contrast to the other variables used to split the sample in Table 5, we have also estimated models with interaction terms between GPA and the number of semesters in high school to provide more evidence on the crime reducing effect of student performance. In the models reported in Table 6 we have simply included interaction terms between the instruments and GPA in the first stage. All interaction terms are highly significant. GPA reduces the impact of number of semesters in high school on all imprisonment variables. For all dependent variables, the results imply that the effect of high school education is zero for individuals with GPA 4.4, which is 0.5 standard deviations above the mean. This is exactly the same critical level of GPA as we find in OLS models. Likewise, there is no effect of GPA for individuals with 6.5 semesters in high school.

These results indicate that with success in one educational dimension, the other dimension is unrelated to crime. With high skills at the end of compulsory education, the high school career does not have any negative impact on imprisonment. On the other hand, with success in high school education, imprisonment is unrelated to the skills at age of 16.

Table 6
Interaction effects between high school education and GPA.

	(1)	(2)	(3)
	All imprisonment	Days in prison	Custody imprisonment
Number of semesters in high school	−0.0832**	−14.29***	−0.0561**
	(0.0389)	(5.446)	(0.0259)
Number of semesters in high school * GPA	0.0190**	3.286***	0.0128**
	(0.00895)	(1.251)	(0.00694)
GPA	−0.128**	−21.18***	−0.0817**
	(0.0553)	(7.722)	(0.0369)
F-test for instruments (Cragg–Donald Wald F statistic)	20.6	20.6	20.6

Note: 159,799 observations. The model specifications are similar to the models in Table 3, except as indicated. The excluded instruments are the initial instruments at level and interacted with GPA. Standard errors clustered at the county level are reported in parentheses.
** Denotes significance at the 5% level.
*** Denotes significance at the 1% level.

[20] By this extension, the percent of the sample that has been incarcerated increases from 0.76 to 1.35, custody imprisonment increases from 0.14 to 0.21, and the average number of days in prison increases from 0.54 to 1.00.

[21] In percentage terms, the effect of high school education on custody is large for students with GPA above the median. Notice, however, that only 15 students in this group were in custody in the relevant period, making this model voluntary to outliers.

5. Conclusion

This paper estimates the causal effect of education on crime. The causal effect of post-compulsory high school education above the age of 16 is of direct policy relevance both in terms of incentivizing students to stay longer in education and in terms of expanding compulsory education, in contrast to analyses of historical expansion of compulsory education which is only of indirect relevance in this respect. By using Norwegian register data, we find a robust negative effect of post-compulsory education on imprisonment. The causal effect is identified by variation in school supply across school districts and student residences, and imprisonment is measured in ways that to different degrees take the timing and severity of the underlying crime into account.

We find that education has a much larger effect on imprisonment on those induced by school supply to stay longer in high school education than simple average relationships suggest. In addition, the effect seems to be largest for students with low-educated parents and with low prior skills. Prior skills, measured by grade point average (GPA) from compulsory education, have a strong and independent effect on crime. The estimated local average treatment effect of high school education is, however, robust to the inclusion of GPA in the model specification. This finding indicates that the estimated effect is not simply reflecting that high skill students achieve higher educational qualifications. However, the effects of high school education and GPA seem to be interrelated. Our exploratory analysis indicates that avoiding failure either in compulsory education (low GPA) or in high school (early dropout) is sufficient to escape from future crime.

These results are in accordance with economic theory. Educational performance improves labor market outcomes and thus decreases the expected gain of crime. The present empirical literature cannot, however, say much about the mechanisms driving the results. Lochner and Moretti (2004) discuss some mechanisms other than those that follow from traditional utility maximization models. If the stigma of a criminal conviction is larger for white collar workers than for blue collar workers, the expected loss for highly educated individuals from criminal activity extends beyond the time spent in prison. Higher educational attainment may also alter an individual's patience, risk aversion, and the psychological costs of breaking the law, which might increase the cost to the individual of possible future punishment and deter individuals from committing crime. The relative importance of different potential mechanisms cannot be revealed in register data such as those used in the present paper.

Appendix A

Table A1
Descriptive statistics.

	Population			Regression sample		
	Observations	Mean	Standard deviation	Observations	Mean	Standard deviation
Dependent variables						
All imprisonment	174,067	0 .0081	–	159,799	0.0076	–
Days in prison	174,067	0.600	10.4	159,799	0.536	9.67
Custody imprisonment	174,067	0.0015	–	159,799	0.0014	–
Education variables						
Number of semesters in high school	174,067	6.55	1.81	159,799	6.70	1.55
Graduated	174,067	0.665	–	159,799	0.695	–
GPA	165,612	3.95	0.83	159,799	3.96	0.83
Instruments						
Share of students in vocational study tracks at the county level, lagged one year	159,799	0.492	0.06	159, 799	0.492	0.06
At most 3 high schools within 30 minutes travel time from the student's residence	159,799	0.338	0.473	159,799	0.338	0.473
Socioeconomic characteristics						
Girl	173,938	0.488	–	159,799	0.489	–
First generation immigrants	173,938	0.070	–	159,799	0.036	–
Second generation immigrants	173,938	0.021	–	159,799	0.020	–
Both parents have only compulsory school	173,938	0.182	–	159,799	0.146	–
At least one parent with a high school education	173,938	0.446	–	159,799	0.467	–
At least one parent with a bachelor degree	173,938	0.273	–	159,799	0.285	–
At least one parent with a master or doctoral degree	173,938	0.099	–	159,799	0.102	–
Benefits due to disabilities or diseases	173,938	0.025	–	159,799	0.020	–
Benefits due to private nursing or care	173,938	0.034	–	159,799	0.028	–
Birth month	173,475	6.42	3.39	159,799	6.41	3.36
Married parents	173,862	0.581	–	159,799	0.606	–
Divorced parents	173,862	0.123	–	159,799	0.126	–
Parents never married	173,862	0.296	–	159,799	0.268	–
Parental income in quartile 1	174,067	0.25	–	159,799	0.213	–
Parental income in quartile 2	174,067	0.25	–	159,799	0.261	–
Parental income in quartile 3	174,067	0.25	–	159,799	0.263	–
Parental income in quartile 4	174,067	0.25	–	159,799	0.263	–
Both parents employed	173,938	0.668	–	159,799	0.701	–
Only father employed	173,938	0.133	–	159,799	0.134	–
Only mothers employed	173,938	0.108	–	159,799	0.109	–
Other						
Number of students at compulsory school	174,067	88.4	45.5	159,799	88.7	44.8
District Court identifier	174,067	0.984	–	159,799	1.00	–
Missing District Court identifier	174,067	0.016	–	159,799	0	–
Age 16 when finishing compulsory education	174,067	0.942	–	159,799	1.00	–
Age not 16 when finishing compulsory education	174,067	0.058	–	159,799	0	–
Did not enroll in high school at age 16	174,067	0.061	–	159,799	0.032	–

Table A2
Full model results.

Dependent variable	Semesters in high school (first stage)	All imprisonment	Days in prison	Custody imprisonment
Number of semesters in high school	–	−0.0072**	−1.124**	−0.0048***
		(0.0035)	(0.437)	(0.0018)
Share of students in vocational study tracks at the county level, lagged one year	0.842***	–	–	–
	(0.223)			
At most 3 high schools within 30 minutes travel time from the student's residence	0.076**	–	–	–
	(0.027)			
GPA	0.162***	−0.0087***	−0.533***	−0.0010**
	(0.022)	(0.0010)	(0.124)	(0.0005)
Girl	−0.108***	−0.0091***	−0.733***	−0.0021***
	(0.023)	(0.0007)	(0.061)	(0.0002)
First generation immigrants	0.021	−0.0019	−0.069	0.0018***
	(0.024)	(0.0017)	(0.180)	(0.0006)
Second generation immigrants	−0.023	0.0017	0.333	0.0015
	(0.044)	(0.0025)	(0.351)	(0.0023)
At least one parent with a high school degree	0.270***	−0.0014	0.019	0.0012
	(0.027)	(0.0015)	(0.210)	(0.0008)
At least one parent with a bachelor degree	0.271***	−0.0001	0.140	0.0013
	(0.031)	(0.0016)	(0.206)	(0.0009)
At least one parent with a master or doctoral degree	0.166***	−0.0006	0.125	0.0009
	(0.040)	(0.0013)	(0.155)	(0.0007)
Benefits due to disabilities or diseases	0.007	0.0023	0.155	0.00003
	(0.037)	(0.0022)	(0.212)	(0.0011)
Benefits due to private nursing or care	0.145***	0.0018	0.434**	0.0018
	(0.046)	(0.0016)	(0.177)	(0.0011)
Birth month/10	0.167***	0.00003	0.115	0.0006
	(0.010)	(0.0008)	(0.084)	(0.0005)
Married parents	0.115***	−0.0039***	−0.301***	−0.0005*
	(0.015)	(0.0009)	(0.0874)	(0.0003)
Divorced parents	0.004	−0.0014	−0.159	−0.0006
	(0.011)	(0.0011)	(0.134)	(0.0004)
Parental income in quartile 2	0.010	0.0004	0.046	−0.0005*
	(0.015)	(0.0008)	(0.092)	(0.0003)
Parental income in quartile 3	0.029*	0.0017*	0.080	−0.0004
	(0.014)	(0.0010)	(0.099)	(0.0003)
Parental income in quartile 4	−0.056***	0.0007	−0.078	−0.0002
	(0.014)	(0.0010)	(0.096)	(0.0004)
Both parents employed	0.238***	−0.0075***	−0.402**	−0.0017**
	(0.031)	(0.0017)	(0.158)	(0.0008)
Only father employed	0.125***	−0.0060***	−0.387**	−0.0019**
	(0.030)	(0.0016)	(0.157)	(0.0008)
Only mother employed	0.184***	−0.0053***	−0.275**	−0.0017**
	(0.033)	(0.0016)	(0.117)	(0.0008)
Number of students at compulsory school/100	−0.041*	−0.0023***	−0.133**	−0.0008**
	(0.022)	(0.0006)	(0.0057)	(0.0004)
Cohort 2003/10	0.150	−0.0064	0.416	−0.0002
	(0.107)	(0.0048)	(0.576)	(0.0023)
Cohort 2004/10	−0.070	−0.0042	0.388	0.0001
	(0.170)	(0.0051)	(0.607)	(0.0022)
Observations	159,799	159,799	159,799	159,799

Note: Full results for the models in columns (4)–(7) in Table 3. Standard errors clustered at the county level are reported in parentheses.
* Denotes significance at the 10% level.
** Denotes significance at the 5% level.
*** Denotes significance at the 1% level.

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