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Does School Choice Improve Student Performance?

Kaja Høiseth Brugård
Center for Economic Research at NTNU and Department of Economics,
Norwegian University of Science and Technology

Department of Economics

Norwegian University of Science and Technology
N-7491 Trondheim, Norway
www.svt.ntnu.no/iso/wp/wp.htm

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Kaja Høiseth Brugård
Center for Economic Research at NTNU
and
Department of Economics, Norwegian University of Science and Technology

Abstract

This paper studies the relationship between school choice and student performance for high school students in Norway. The analysis exploits both the fact that the degree of school choice formally differs between counties, and detailed information on travelling distances to high schools, which more closely reflects the students' actual school choice possibilities. Information on students' residence, high school location, and the degree of formal school choice is used to estimate the effect on student achievement in a difference-in-differences-in-differences model specification. In addition, I estimate the effect of school choice on high school graduation rates and university attainment. I find a positive and significant effect of school choice on student performance, and heterogeneity analyses indicates that this effect is entirely driven by the performance of boys.

JEL Classification: I2, I21
Keywords: school choice, high school education, student achievement

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1. Introduction

Increased globalization of trade has coincided with a reduction in the relative demand for unskilled labor in developed countries. Developed countries need high quality educational systems in order to deliver a highly skilled workforce, which can compete in global markets with relatively high wages. In this setting, high school education is very important as a starting point for higher education. Large amounts of resources are spent on public schooling in rich countries such as the United States and Norway. However, this is not fully reflected in results from internationally comparable student tests. These rich countries have similar levels of performance on OECD PISA tests as countries that spend less than half as much per student, such as Estonia, Hungary and Poland, (OECD, 2012).[1]

Thus, do public schools face the right incentives to provide education efficiently? One possible efficiency enhancing policy is to allow students and parents greater freedom through school choice. This is a controversial issue and empirical evidence on the causal effect of school choice is needed. In this paper, I exploit information on students' residence, high school location, and the degree of formal school choice to estimate the effect on student achievement in a difference-in-differences-in-differences model. I examine student performance in high school, the probability of graduating from high school, and the probability of enrolling in higher education.

There are two important mechanisms through which school choice may increase the overall quality of schooling.[2] First, competition between schools might improve the schools' incentives, because they may be forced to improve when faced with competition instead of just being local monopolies. This is the mechanism of interest in this paper. Will public schools subject to competition produce higher achieving students? A much discussed paper by Hoxby (2000) concludes that a greater degree of Tiebout choice in the US increases public school productivity.[3] The second possible mechanism is that private schools may generally be better than public schools; if so, school choice policies that increase private school enrollment might increase overall achievement. However, only about five percent of Norwegian students

[1] These results are important because they could be one way of predicting future economic growth. See Hanushek and Kimko (2000), Hanushek and Woessmann (2008), and Hanushek and Woessmann (2009).
[2] See Friedman (1962). More recent examples include Hsieh and Urquiola (2006) and Bölhmark and Lindahl (2008).
[3] See also Rothstein (2007) and Hoxby (2007).

attend a private high school; therefore, the present analysis is limited to students enrolled in public high schools.[4]

These are arguments in favor of school choice. However, school choice may not be positive for all students. Epple and Romano (1998) suggest that high-ability students may create positive spillover effects onto other students. Hence, the sorting effects of school choice could be negative for average performance. It could lead to a system where high-ability students select themselves into particular schools, and the positive spillover effects for these students are not enough to counteract the negative effects for the other students who miss out on these positive peer effects (Epple and Romano, 1998). In addition, school choice could lead to the most involved families selecting themselves into a few schools, thus reducing the parental monitoring of other schools, which might reduce the effort incentives in these schools (McMillan, 2004).

An empirical challenge when analyzing the effect of school choice is omitted variables. One cannot simply compare students subject to or not subject to school choice, because there could be both observable and unobservable differences across choice regimes. Even if a wide range of socioeconomic characteristics are included in the empirical model, there may still be unobserved variables that affect student performance. To control for these additional omitted factors, I perform a difference-in-differences-in-differences analysis.

In Norway, counties are responsible for high school education, and some of the 19 counties offer school choice among all high schools in the county. I denote this formal school choice. Some counties have a system with neighborhood catchment areas, and thus do not offer school choice. Hence, formal school choice is decided by local county authorities. I also exploit the fact that, even though a student lives in a county with formal school choice, actual choice might be limited due to few high schools nearby the student's residence, which results in long travelling distances. This could affect student performance. I address this issue by including a geographical variable measuring potential school choice, based on an indicator that takes into account travelling distances from the students' residences to nearby high

[4] A third argument in favor of school choice, presented in Gibbons et al. (2008), suggests that school choice also could be welfare-improving through reallocation of students to schools that better match their preferences and needs.

schools. As a result, this paper analyzes educational outcomes for students subject to different degrees of school choice.

Student performance is measured as the difference between the grade in Norwegian language obtained in high school and in compulsory (pre-high school) education. Thus, the regression model could be interpreted as a difference-in-differences-in-differences specification. The results indicate a positive and significant effect of school choice on student performance. However, heterogeneity analyses suggest that this effect is driven entirely by the performance of boys. In addition, I find a positive effect on both high school graduation and the probability of attending higher education.

The paper is organized as follows: Section 2 reviews previous literature and section 3 presents the relevant institutional features. Section 4 presents data and descriptive statistics, while endogeneity issues and identification strategies are discussed in section 5. The results, together with some robustness checks, are reported in section 6. Section 7 concludes.

2. Literature

This paper explores possible effects of school choice, and is related to the literature on school vouchers. The introduction of vouchers often leads to a larger degree of school choice, because vouchers make private schools a more realistic option, especially for low-income students.

Figlio and Hart (2010) estimate the effect of a school voucher, for low-income students in Florida, on student performance. In addition to the voucher, they also use geographical variables, to account for actual private school options available to the students. More specifically, they examine whether students in schools that face a greater threat of losing students to private schools, due to the introduction of the voucher, improve their test scores more than students in schools that face less pronounced threats. Due to the announcement of the program one year ahead of implementation, Figlio and Hart (2010) are able to estimate the pure competition effect in a difference-in-differences framework. Figlio and Hart (2010) find that public schools subject to more competitive pressure from private schools raised their test scores the most following the introduction of the voucher.

My approach is similar in spirit to Figlio and Hart (2010) in that I introduce geographical variables in the empirical model that captures differences in school options available to the students. However, while they compare students subject to different degrees of private school options before and after a policy change, I compare students in counties with different degrees of formal school choice.

Similar to Lavy (2009), I examine school choice within a public school system. Lavy (2009) investigates dropout, student achievement, and behavioral outcomes in Israeli public schools. He exploits the termination of an inter-district busing program in Tel Aviv that led to school choice between public schools. By using both difference-in-differences estimations and an RD design, Lavy (2009) finds that increased choice has positive effects on all outcomes.

Several other papers examine the effect of a general school choice reform on student achievement. Hsieh and Urquiolo (2006) and Bölhmark and Lindahl (2008) look at a nationwide school reform, in Chile and Sweden, respectively. In Chile, provision of vouchers opened up school choice between both private and public schools. By comparing municipalities with different private school enrollment, Hsieh and Urquiolo (2006) find no effect on educational outcomes as measured by test scores, repetition rate, and years of schooling.

Bölhmark and Lindahl (2008) investigate both short- and long-term effects of a nationwide school reform in Sweden in 1992. Prior to the reform, public schools were local monopolists in local school markets. With the reform came the introduction of vouchers and choice between public and private schools. The authors use within-municipality variation to examine whether higher levels of private enrollment at the compulsory school level affected overall student performance at the compulsory school level and overall long-term educational achievement. They estimate only small effects on student performance, and no effects on long-term educational outcomes. Other examples in this category include Gibbons et al. (2008), who examine choice and competition effects in the UK, and Ladd and Fiske (2003). Using data from New Zealand, Ladd and Fiske (2003) conclude that competition, as perceived by teachers, has negative effects on student learning.

Papers studying smaller choice programs exploit lotteries to ensure random assignment of treatment. Howell et al. (2000) and Krueger and Zhu (2004) investigate early voucher programs in the US, while Angrist et al. (2002) study vouchers distributed through lotteries in Columbia. Howell et al. (2000) estimate a positive effect on test scores for African American students who switched from public to private schools. However, Krueger and Zhu (2004) claim that this result is sensitive to the sample size and race/ethnicity definitions. Angrist et al. (2002) find that lottery winners have increased educational attainment and academic achievement.

Cullen et al. (2006) and Hastings et al. (2006) also exploit school admission based on lotteries. However, these papers examine choice between public schools only. While neither of the papers finds positive academic outcomes for the average student, Hastings et al. (2006) find significant test score gains for children of parents whose choice revealed a strong preference for academic quality. A third paper investigating a public choice plan is Hastings and Weinstein (2008). They analyze the effect of information on school choice and academic achievement. The authors argue that school choice increased when information about school-level performance was made transparent and easily accessible for low-income families. When parents were informed of the school's academic achievement, more parents chose higher-scoring schools for their children. Hastings and Weinstein (2008) also examine the effect of attending a higher-scoring school on student performance, and find positive effects. Another paper targeting school choice for low-income families is Rouse (1998). She exploits a Parental Choice Program for a small group of low-income families in Milwaukee. Rouse (1998) compares test scores of students selected to attend a participating private school, with those of unsuccessful applicants and other students from the Milwaukee public schools. Her findings indicate a positive effect on math test scores for students in the choice program.

The literature on gender differences in performance under different incentive schemes motivates my examination of whether boys and girls respond differently to school choice. The findings of Gneezy et al. (2003) suggest that women are less effective than men under competitive environments. Örs et al. (2008) examine an entry exam to a very selective French business school, and find that males perform relatively better than females on the exam compared to prior achievement. Hopland and Nyhus (2013) use Norwegian survey data on student motivation and examine the effect of school choice and increased competition. By

using a difference-in-differences approach, they find that the motivation for boys seems to be unaffected by the increased competition, while there is a negative effect on girls' motivation.

To my knowledge, few analyses of school choice have been conducted using Norwegian data. However, Machin and Salvanes (2010) use the transition from rigid neighborhood catchment areas to school choice, in Oslo in 1997, to investigate the effect on housing prices. They find that, after the choice reform, the relationship between housing prices and school performance was significantly weakened, indicating that parents value better performing schools. However, they do not analyze student achievement. Haraldsvik (2012) investigates the effect of a similar school choice reform in another Norwegian county, Hordaland, in 2005, but focuses on students' performance in junior high school when admission to high schools changes from neighborhood catchment areas to school choice. She finds a positive effect on student performance when school choice is implemented, but does not analyze performance in post-compulsory education. The present paper differs from the two papers above as it investigates the effect of school choice on student achievement in post-compulsory education. In addition, both these papers look at a reform in one specific county, while the present paper looks at the whole country, and explores variation across many counties interacted with the students' actual choice possibilities.

Overall, the evidence of school choice programs and reforms on student performance is mixed. This motivates further research and alternative identification strategies such as the one presented in this analysis. As it is not clear that choice options and competition affect boys and girls equally, it is interesting to look at possible differences in student performance for boys and girls in more and less competitive areas.

3. Institutions

3.1 School system

Compulsory education in Norway consists of 9 years of schooling from age 7 to age 16. [5] Everybody graduates from compulsory school at the end of 10th grade; grade repetition is

[5]Some students started school at age six, due to early implementation of a compulsory school reform increasing compulsory schooling by one year. The school system in Norway is relatively homogenous. Less than two percent of all students attend a private compulsory school. Private high schools enroll about five percent of the students.

non-existent. [6] After finishing compulsory education, students may choose to leave school or continue with a non-compulsory high school education. Over 95 percent of each cohort chose the latter.

When starting high school, students could choose between 15 different study tracks in the empirical period. Students enroll in two broad categories of study tracks: Academic study tracks and vocational study tracks. An academic study track consists of three years of schooling and leads to a high school diploma, which is required for university enrollment. Vocational study tracks certify for work in a number of jobs and include industrial design, health and social work, mechanics, and electrical trades. The general academic study track is the largest track and includes about 45 percent of enrolled students.

At the end of compulsory education, all students receive a diploma containing 13 grades in different subjects on a scale from 1 (low) to 6 (high), set by teachers. Norwegian language is one of the 13 grades. There is also a final written exit exam at the end of compulsory education. However, students do not take this exam in all subjects; they are chosen randomly to complete an exam in Norwegian language, English language or mathematics. Around 20 percent of the students are assigned to take the written exit exam in Norwegian language at the end of compulsory education. The Norwegian Directorate for Education and Training prepares the exams, while local authorities assign examination subjects to schools and individual students, given clear instructions from the Directorate. Neither the teachers nor the schools have any influence in this respect. The exam results are determined anonymously by two external examiners assigned to each student.

All students graduating from an academic study track in high school have to complete an externally given exit exam in Norwegian language. This national exam is identical for all these students, and graded on a scale from 0 (low) to 6 (high).[7] A grade of 2 or higher is required to pass the exam and graduate from high school. The dataset only includes students

[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 the birth cohort and the student may postpone starting school with one year if not considered mature enough. The parents together with the school and psychologists make this decision.

[7] National exams are given in other subjects as well, but these subjects vary across students due to different study programs.

that both passed the exam and graduated from high school. I focus on students completing an academic study track.

I obtain a value added student performance measure by comparing the teacher set grade in Norwegian language from compulsory education to the exam grade in Norwegian language from high school. Because all compulsory school graduates receive a teacher grade in all subjects, but all of them do not take the compulsory school exit exam in Norwegian language, I use the teacher set grade from compulsory education and the exam grade from high school to be able to include the whole sample.

Students have a legal right to enroll in one out of three individually ranked high school study tracks, a rule that is followed without exception by each county. Whether the students are enrolled in the first, second, or third preferred track depends solely on their grade point average (GPA) from compulsory education. All students have a legal right to complete high school, within a time frame of five years.[8] The main rule for high school applicants is to apply in their county of residence.[9]

3.2 School choice

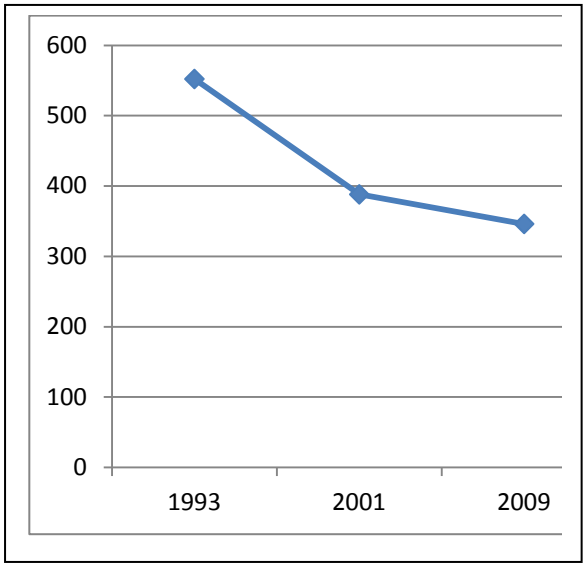
Municipalities are responsible for compulsory education, while counties are responsible for high school education. Providing high school education is the counties' most important task, and accounts for over 50 percent of total county spending. The counties are financed by grants from the central government. During compulsory education, students are allocated to schools based on fixed neighborhood catchment areas. In high school, however, counties employ different admission policies. Some counties define specific catchment areas, some have school choice and student selection based on achievement in compulsory school, and others have quasi-systems. Examples of these quasi-systems include students being allowed to choose freely within a certain area of the county, or having the nearest school as a mandatory first choice, but being allowed to choose the second and third choice schools freely. That way, students in the same county may experience different degrees of choice, because choice options vary within different areas. I focus on counties where all students faced the same system, either school choice or no school choice and strict neighborhood catchment areas.

[8] There is an option for students to apply for a transfer to another school or study track.
[9] There are some exceptions for private high schools and high schools abroad. In addition, some counties have agreements with neighboring counties for students living close to the county boarder.

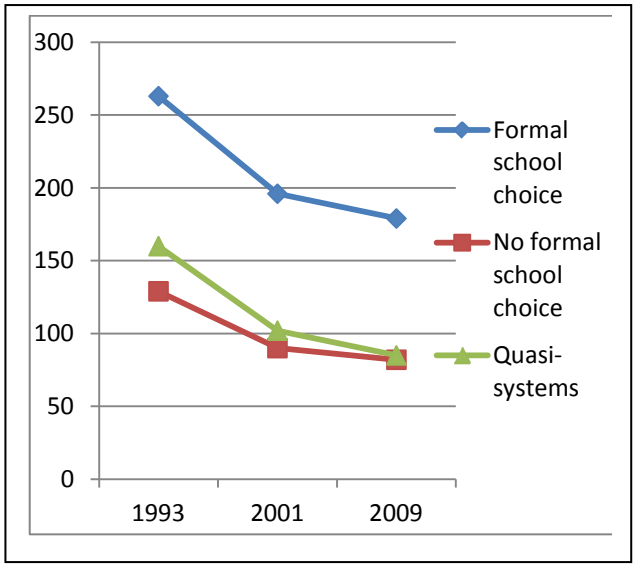
The counties vary in their size, population and degree of urbanization. All these factors influence the density and location of high schools within each county. This will also affect high school choice options. Thus, even though a student lives in a county with formal school choice, actual choice might be limited because there are few high schools nearby and long travelling distances. Causal evidence indicates that the variation in school choice across counties is mostly historical. Even though school choice has an ideological bias, there have been few changes in the last 20 years, (Falch and Naper, 2011).[10] Panel A in figure 1 presents changes in the number of high schools in Norway from 1993 to 2009. It might seem like there is a dramatic reduction in the number of high schools over the last 20 years, but in most counties it is actually just reorganization. A lot of smaller schools have been merged with bigger schools and now only count as one school in official records. Panel B presents changes in the number of high schools divided by the three different choice systems. The figure shows the same trend for all three categories.

Figure 1: Number of high schools in Norway from 1993-2009

Panel A: All counties



Panel B: Divided by choice systems



Source: Statistics Norway

[10] Some changes occur. Oslo changed from a mixed system to a system of school choice in 1997; see Machin and Salvanes (2010). In the city of Trondheim, the exact opposite change was implemented after the empirical period of this paper, while more choice has been introduced in Bergen. The arguments for changes are typically ideological.

4. Data and descriptive statistics

The student data, including school identifiers for both the compulsory school from which the students graduated, and the high school in which they enrolled, is obtained from the National Educational Database of Statistics Norway. It consists of all students finishing compulsory education during the years 2002-2004. The student information is matched with information about their parents and socioeconomic characteristics. I limit the sample to normal-aged individuals, i.e., those who turned 16 in the year they finished compulsory education.

Details on data reduction are presented in appendix Table A1. As can be seen from this Table, limiting the sample to students who completed an academic study track reduces the number of observations by more than 50 percent. Information about whether the school is a private or a public school is missing in 1.44 percent of observations. A very small proportion of the students, about two percent, were enrolled in private high schools. The main regression sample includes only individuals living in a county with a clear choice policy, either formal school choice or neighborhood catchment areas. Students living in counties with so-called quasi-systems, where choice options vary within the county, are excluded, reducing the sample by about 10 percent of the observations. I include only the students who passed the Norwegian exam at the end of high school within five years of completing compulsory education.

4.1 Formal school choice

School choice possibilities differ between counties because the choice decision is made by local county authorities. The school choice data are from Haraldsvik (2004). In her classification, school choice is measured on a scale from 0 to 1, with municipalities within the county as the measurement unit. Municipalities with formal school choice are given the value 1, while municipalities with no choice, i.e., neighborhood catchment areas, are given the value 0. Municipalities with some degree of choice are given the value 0.2, 0.5 or 0.8, depending on the degree of choice, where a higher number represents more formal school choice. Counties with municipalities in one of these categories between 0 and 1 are defined as quasi-systems and excluded from the analysis.

Table 1 presents the different degrees of choice for all individuals divided by county and municipalities. Included in this Table are the regression sample and students living in counties with quasi-systems. The Table shows that 9 of the 19 counties have formal school choice in all municipalities, which accounts for about 50 percent of the students. Around 26 percent of the students live in counties with quasi-systems, while 23 percent of the students have no school choice at all.

Table 1: Degree of school choice

Choice	County	Municipalities	Individuals
	Observations	Observations	Observations
Formal school choice	9	152	33,959
No school choice	4	88	15,408
Quasi-systems	6	191	17,653
Total	19	431	67,020

In the main analysis, I focus on counties that provide equal opportunities to all their students, either formal school choice for all students in the county or no school choice at all. Hence, I only use variation across counties in the main regressions. However, I will perform a robustness analysis where counties with quasi-systems are also included.

4.2 Potential school choice

Norway is a sparsely populated country and high schools are often localized in cities and community centers. This will affect choice options for students living in counties with formal school choice. Long travelling distances to nearby high schools will reduce actual school options for these students. Long commuting distances might also affect student performance. I address this issue by introducing a variable which represents potential school choice in the form of a geographical measure that takes into account numbers of high schools nearby the student's residence. Norway is divided into about 14,000 wards, where a ward is a small geographical unit, and the geographical variable includes information about the student's residence measured at the ward level.[11] Hence, it gives a very good indication of the student's location.

[11] Residence is recorded as the midpoint of the ward's population. There are on average 6.9 students per ward in the regression sample.

The geographical measures are provided by Falch et al. (2013). The variable is defined as a dummy variable equal to 1 if there are more than five high schools within a 30 minute drive from the student's residence. Detailed data on the public road network are used to identify both the length and speed limit for each road segment. Then the number of schools within 30 minutes of driving from the student's residence is calculated using ArcGIS Network Analyst. For further details on the geographical variable, see Falch et al. (2013). Descriptive statistics for the most important variables are presented in Table 2. The Table shows that over 70 percent of the students in the regression sample had more than five high schools within a 30 minute drive from their residence. In counties with formal school choice, 76 percent of the students have more than five high schools nearby, while this is the case for 64 percent of the students living in counties without formal school choice (not shown in Table).

4.3 Outcomes

4.3.1 Student achievement

In the baseline model, student achievement is the value added measure. It is the difference between the grade in Norwegian from high school and from compulsory education. The grade from high school is the grade on the external written exit exam in the academic study track. Table 2 shows that the average grade in Norwegian from high school is 3.45, while the average grade from compulsory education is 4.37.[12]

Girls perform better than boys in Norwegian in both compulsory education and in high school. There is a higher share of girls in the dataset, due to the fact that more girls start an academic study track. About the same share of boys and girls have formal and potential school choice.

[12] The grades are close to normally distributed on a scale from 1 to 6. Due to selection into the academic study track, the average grade decline.

Table 2 Descriptive statistics for the outcome and choice variables

	All		Boys		Girls	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Grade from high school exam in Norwegian language	3.449	0.948	3.373	0.941	3.502	0.949
Grade in Norwegian language from compulsory education	4.371	0.760	4.165	0.769	4.513	0.720
Difference in Norwegian grade between high school and compulsory education	-0.921	0.898	-0.791	0.904	-1.010	0.883
Enrolling in higher education	0.685		0.659		0.703	
Formal school choice	0.688		0.701		0.679	
Potential school choice	0.725		0.705		0.707	
Observations	49,367		20,114		29,253	
Graduated from high school	0.708		0.664		0.753	
Observations	113,204		57,648		55,556	

4.3.2 Other outcomes

I will also examine the effect of school choice on the probability of graduating from high school and the probability of being enrolled in higher education five years after the completion of compulsory education.

When examining the effect of school choice on the probability of graduating from high school, the sample size increases, because the original regression sample only includes students who have graduated from an academic study track. The sample now consists of all students in the three cohorts, including those who graduated from a vocational study track and those who did not graduate. Because school owner status is unknown for students in vocational study tracks and for dropouts, it is not possible to exclude students in private schools from the sample. Excluding students in counties with quasi-systems, the sample consists of 113,204 students, and Table 2 shows that about 71 percent of the students graduated from high school within five years after finishing compulsory education. A higher proportion of girls than boys graduate from high school.

When estimating the effect on the probability of enrolling in higher education, I use the same sample as earlier, i.e., only students graduating from an academic study track. This is due to the fact that, in principle, only these students can apply for enrollment in higher education. Table 2 shows that about 70 percent were enrolled in higher education five years after the completion of compulsory education. There is also a higher proportion of girls enrolled in higher education compared to boys.

4.3.3 Control variables

Appendix Table A2 presents descriptive statistics for socioeconomic characteristics and other control variables for the regression sample. Hence, the Table presents students in the relevant cohorts that graduated from an academic study track, and consists of 49,367 individuals. This is the sample consistent with a clear county policy regarding formal school choice. There are over 50 percent girls in the sample. There are 2.2 percent first generation immigrants and 2.1 percent second generation immigrants. 7.4 percent of the students have parents with no schooling beyond compulsory education, while over 50 percent have parents with higher education (bachelor degree or higher).

Benefits due to disabilities or diseases before the age of 18 are received by 1.5 percent of the sample, while 1.6 percent have received benefits to support needs for private nursing or care. At age 16, around 70 percent of the individuals have married parents, while 11.2 percent have divorced parents. Over 75 percent of the students had two employed parents. The students are pretty evenly distributed across the three cohorts.

5. Identification

I want to compare student achievement in counties with and without school choice, because school choice could have a competitive effect on public schools. However, which counties have formal school choice and where different families and students are located might not be random. As formal school choice is decided by the local county authorities, political composition could by an omitted variable. Political composition could be correlated with school choice, due to the fact that non-socialists generally are supporters of more choice in the educational system. If the number of non-socialists in the county council also affects student achievement, this could bias the estimates.

I exploit the fact that the relevance of formal school choice depends on the number of high schools nearby the student's residence (potential school choice). Hence, actual school choice is a combination of both having formal school choice and potential school choice. In addition, a reasonable assumption is that past academic achievement affects current academic achievement. To address this issue, student achievement is measured as the difference between the student's performance in Norwegian language in high school and compulsory education.

In the baseline model, I address the omitted variable problem by using a difference-in-differences-in-differences estimation. The first difference is the difference in student achievement for students living in counties with formal school choice, with and without potential school choice, shown in equation (1):

$$(1)\quad DID_{FormalChoice} = \left(\overline{y}_t - \overline{y}_{t-1}\right)^F_{>5schools} - \left(\overline{y}_t - \overline{y}_{t-1}\right)^F_{\leq 5schools}$$

where $\bar{y}_t$ is average student achievement at the end of high school, and $\bar{y}_{t-1}$ is average student achievement at the end of compulsory education.

The second difference is the difference in student achievement for students living in counties with no formal school choice, with and without potential school choice, shown in equation (2):

$$(2)\ DID_{NoChoice} = \left(\bar{y}_t - \bar{y}_{t-1}\right)^{N}_{>5 schools} - \left(\bar{y}_t - \bar{y}_{t-1}\right)^{N}_{\leq 5 schools}$$

Thus, the third difference is the difference in student achievement between these two differences. The difference-in-differences-in-differences is shown in equation (3):

$$(3)\ DIDID = DID_{FormalChoice} - DID_{NoChoice}$$

The main identifying assumptions are that (1) average differences in test score changes between students living in an area with many high schools and students living in an area with few high schools would be the same in all counties if no county had formal school choice, and (2) the existence of formal school choice should not affect the type of students living in areas with many/few high schools.

The difference-in-differences-in-differences strategy can be framed as a regression model given by equation (4):

$$(4)\ y_{igct} - y_{igct-1} = \alpha_{cx} + \beta_1 SC_c + \beta_2 R_{gc} + \beta_3 SC_c * R_{gc} + X_{igc}\beta_4 + \varepsilon_{igct}$$

where y_{igct} is student achievement in high school for student i in ward g in county c at time t and y_{igct-1} is student achievement from compulsory education. α_{cx} is county times cohort (x) fixed effects, SC_c is a dummy variable equal to 1 if county c had formal school choice, and R_{gc} is a dummy variable equal to 1 if there are more than five high schools within a 30 minute drive from the student's residence (potential school choice). X_{igc} is a vector of the control variables presented in appendix Table A2, and ε_{igct} is the error term. The parameter of

interest is β_3, and this interaction term shows the effect of school choice for students that have both formal and potential choice compared to those with no choice.

The present paper is different from some of the other studies concerning school choice, as it does not include any analysis of the private school market. I do not investigate the results of a major reform in the Norwegian school system, such as the introduction of a voucher or a change in the schooling law, as in Bölhmark and Lindahl (2008) and Hsieh and Urquiola (2006). I only examine public schools and the possible extra competition effect in counties where students face both formal and potential school choice. Due to the small percentage of students in private high schools, there should be limited sorting problems regarding which students enroll in public high schools. Motivated by the literature that suggests differing performance by boys and girls under various incentive schemes, I perform separate regressions for each of the two genders. Later, I also present several robustness checks and heterogeneity analyses.

6. Main results

Results from simple descriptive statistics corresponding to the difference-in-differences-in-differences approach are presented in Table 3. Panel A presents results for students living in counties with formal school choice. The panel shows the difference in grades from high school and compulsory education for students with and without potential school choice. Students subject to potential school choice have 0.14 grade points higher grades in high school on average, while they have 0.04 grade points lower grades in compulsory education. The value added for this group is thus 0.18 grade points. Panel B presents similar data, but for students with no formal school choice. The value added for this group is only 0.05 grade points.

Table 3: Difference-in-differences-in-differences, achievement in Norwegian language

Panel A	Formal school choice		
	Potential school choice	Not potential school choice	Difference
High school grade	3.50	3.36	0.14
Compulsory school grade	4.35	4.39	-0.04
Difference	-0.85	-1.03	0.18
Observations	25,958	8,001	33,959
Panel B	No formal school choice		
	Potential school choice	Not potential school choice	Difference
High school grade	3.44	3.37	0.07
Compulsory school grade	4.40	4.38	0.02
Difference	-0.96	1.01	0.05
Observations	9,812	5,596	15,408
Panel C	Difference-in-difference-in-difference		
Formal school choice	0.18		
No school choice	0.05		
Difference-in-differences-in-differences	0.13		

The simple difference-in-differences-in-differences estimate is shown in the third row of panel C. It is positive, and indicates that living in a county with formal school choice and, in addition, having more than five high schools to choose between, increases student performance by 0.13 grade points. This is an effect of about 12 percent of a standard deviation of the value added measure. Notice that, because the standard deviation of the high school grade and the value added measure are similar, the effect is also close to 12 percent of a standard deviation of the high school achievement measure.

The same estimate is replicated in column (1) of Table 4. No controls are included in this model. The effect of school choice, which is an interaction between formal school choice and potential school choice, is highly significant. The standard errors are clustered at the county times cohort level. In column (2), fixed county times cohort effects are included in the model. The school choice coefficient is reduced in magnitude, but still highly significant. Column (3) is the baseline difference-in-differences-in-differences regression and also includes socioeconomic characteristics. The interaction effect is slightly reduced, but is still significant at the 5 percent level. Living in a county with formal school choice and having potential school choice increases student performance by 0.073 grade points, which is 6.5 percent of a standard deviation of the value added measure. The full model for column (1)-(3) in Table 4

is presented in appendix Table A2. The effects of the socioeconomic characteristics are as expected.

Table 4: Effects of school choice

	(1)	(2)	(3)	(4)	(5)
		All students		Boys	Girls
School choice	0.132***	0.090**	0.073**	0.130***	0.040
	(0.045)	(0.039)	(0.033)	(0.041)	(0.041)
Formal school choice	-0.021				
	(0.035)				
Potential school choice	0.050	0.050*	-0.004	-0.021	0.006
	(0.031)	(0.028)	(0.024)	(0.030)	(0.031)
County*cohort fixed effects	No	Yes	Yes	Yes	Yes
Socioeconomic characteristics	No	No	Yes	Yes	Yes
Observations	49,367	49,367	49,367	20,114	29,253

Note: Standard errors clustered at the county and cohort level are reported in parentheses. *, **, *** denote significance at the 10, 5 and 1 percent level, respectively. The dependent variable is difference in student achievement in high school and compulsory school. The variable school choice is an interaction between formal school choice and potential school choice.

In the literature on gender specific performance under different incentive schemes, several papers find boys to be more responsive to competition. This is supported in my results. Column (4) in Table 4 indicates a larger effect of school choice for boys, compared to the baseline regression in column (3). School choice increases boys' performance by 0.13 grade points, which is about 12 percent of a standard deviation of the value added measure. The effect is highly significant. The same regression, estimated just for girls, in column (5), finds a much smaller, insignificant result.

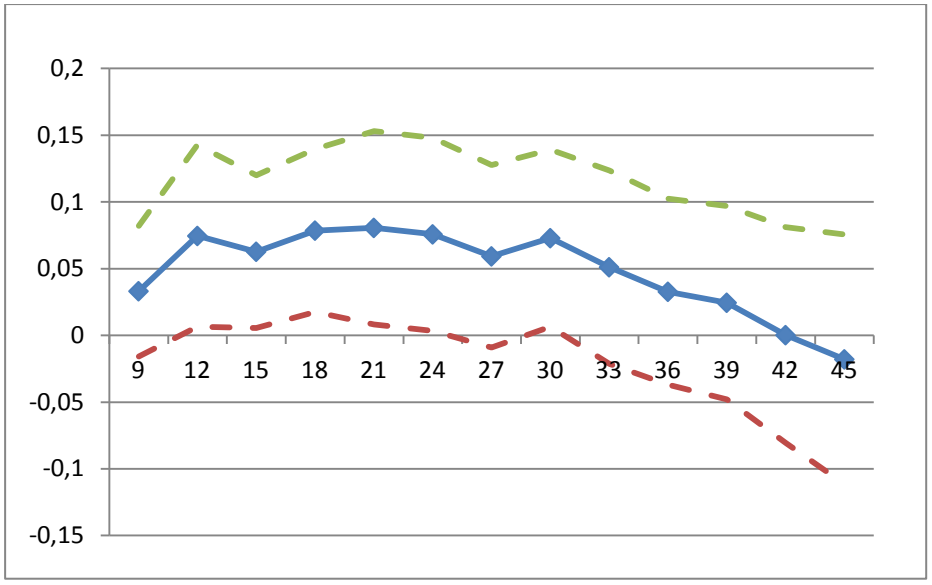
6.1 Robustness

Next, I present some robustness checks of the results. To investigate whether the cutoff values for the geographical measure drive the results, figure 2 presents the effect of school choice on student performance for several different travel time cutoffs and number of schools cutoffs. In Panel A, the travel time to more than five different schools varies from 9 to 45 minutes. The effect is sTable in the interval between 12 and 30 minutes of travel time. A longer travel time might indicate that the students do not have an actual choice anymore, and may explain the decreasing effect on student performance. In Panel B, I vary the number of schools within a travel time of 30 minutes. As expected, there is no effect when there are few schools, but the

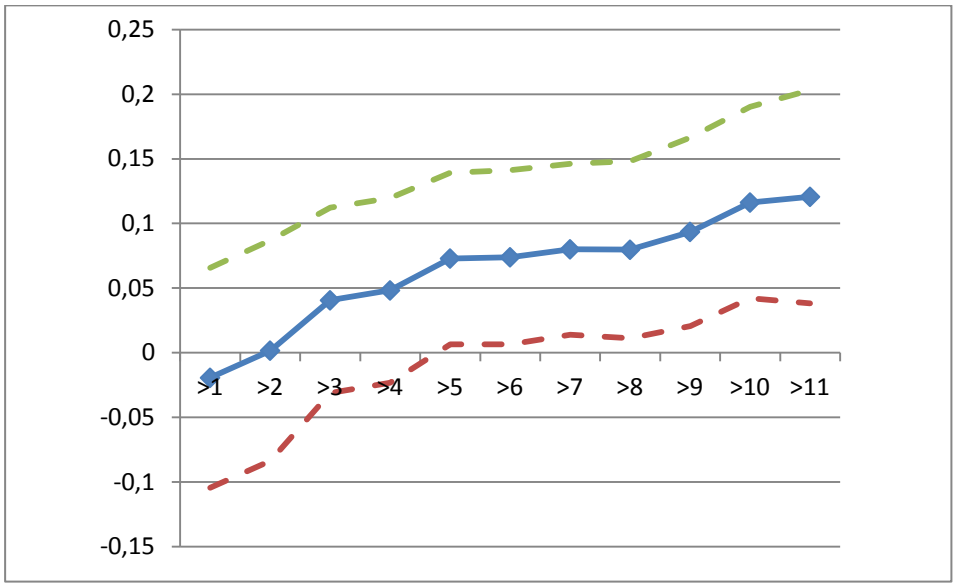
effect is increasing in the number of schools. The effect on student performance is pretty sTable in the interval raging from more than five to more than nine high schools. Thus, using more than five high schools in measuring potential school choice seems like a conservative choice.

Figure 2: The effect of school choice on student performance with 95 percent confidence interval, different travel time and number of schools

Panel A: Different travel time from the student's residence



Panel B: Different numbers of schools within 30 minutes travel time from the student's residence



There could be other skills that affect student achievement in high school, which indicates that there could be some additional omitted variables regarding previous achievement. As a result, I include grade point average (GPA) from compulsory education as an average measure of these skills. The results are presented in panel A of Table 5. However, the effect of school choice is very similar to the baseline regressions in column (3) in Table 4. Due to the different effects for boys and girls found in Table 4, I will continue to split the sample by gender to analyze the robustness of this result as well. The gender results in column (2) and (3) in Table 5 are also similar to the results in Table 4.

Table 5: Robustness analyses related to previous achievement

Panel A. Including GPA as a control	All students	Boys	Girls
School choice	0.067**	0.113***	0.039
	(0.032)	(0.038)	(0.041)
Observations	49,367	20,114	29,253
Panel B. Exam in Norwegian in compulsory education	**All students**	**Boys**	**Girls**
School choice	0.149***	0.265***	0.080
	(0.052)	(0.218)	(0.056)
Observations	10,500	4,265	6,235

Note: Standard errors clustered at the county and cohort level are reported in parentheses. *, **, *** denote significance at the 10, 5 and 1 percent level, respectively. The dependent variable is difference in student achievement in high school and compulsory school. The variable school choice is an interaction between formal school choice and potential school choice. The model specifications are similar to the model specification in column (3) in Table 4, except as indicated.

Bölhmark and Lindahl (2008) argue that one reason they were unable to find long-term effects of school choice might be due to the fact that public schools didn't raise their quality, but only changed the grading standards. Figlio and Hart (2010) criticize their analysis for not having an objective measure of test scores. This analysis might be subject to similar criticism because the lagged achievement measure is the grade in Norwegian language set by teachers at the end of compulsory education, which is not an objective measure of achievement. Thus, there are possible endogeneity problems connected to this grade measure. In addition, there is some evidence that grading practices vary across teachers; see for example Figlio and Lucas (2004) and Bonesrønning (2004). This indicates that the teacher set grade in Norwegian language measures lagged achievements with some error. To the extent that this varies across counties, it is captured by the county fixed effects.

To further address these measurement problems, I perform a robustness check where I use the result on the externally graded exit exam in Norwegian language from compulsory education instead of the grade set by the teacher.[13] In panel B of Table 5, the grade in Norwegian language set by teachers is replaced by the grade from the external exit exam. This reduces the sample size to 10,500 observations. The effect of school choice is now much higher, and it also has a lower standard error, being significant at the 1 percent significance level. Column (2) shows a large increase in the effect for boys, which is highly significant, while column (3) shows no significant effect for girls. This is a much smaller sample, but it does replicate the same qualitative effects, which indicates a stronger effect for boys. When replacing the exam grade with teacher set grade in the small sample, the results are similar (not shown in Table). At least this suggests that the baseline OLS regression do not overestimate the results.

To address the problem of small sample size in the analysis above, I instrument the teacher set grade in Norwegian with the exam grade from the actual exam completed at the end of compulsory education. I use the average of the exam grades in the three different subjects: English language, Norwegian language and mathematics as an instrument for the grade in Norwegian language set by the teacher. In addition, this model includes dummy variables for each exam subject, to control for differences in average grading. In this case, the dependent variable will be the exam grade in Norwegian from high school, and the grade from compulsory education will be included as a right-hand side variable in order to be instrumented. The results are shown in Table 6.

The first three columns present reduced form and first and second stage regressions for the whole regression sample. The F-value in column (2) indicates that the average exam grade is a strong instrument. The effect of school choice in column (3) does not change much from the baseline regression in column (3) in Table 4. The effect of student achievement in compulsory education is close to one, which indicates that the value added specification is reasonable. Columns (4) and (5) present the second stage regressions for boys and girls, respectively. The effect of school choice for boys is also larger here than in the baseline regression and statistically significant. There is no effect of school choice for girls.

[13] A disadvantage with this approach is the small number of students actually assigned to take the exam in Norwegian language, only about 20 percent.

Table 6: Models using exam grades as instrument for teacher set grade at the compulsory school level

Sample	Reduced form, All students	1. stage, All students	2. stage, All students	2. stage, Boys	2.stage, Girls
Grade in Norwegian from compulsory education			1.056***	0.963***	1.126***
			(0.014)	(0.017)	(0.020)
School choice	-0.010	-0.086**	0.081**	0.133***	0.049
	(0.034)	(0.035)	(0.033)	(0.039)	(0.042)
Exam grades	0.410***	0.388***			
	(0.005)	(0.004)			
English exam	-0.037**	-0.036**	-0.002	0.005	-0.007
	(0.016)	(0.016)	(0.020)	(0.022)	(0.023)
Mathematics exam	0.057***	0.048***	0.007	0.009	0.005
	(0.015)	(0.017)	(0.019)	(0.022)	(0.021)
Observations	48,359	48,359	48,359	19,720	28,639
F-value		9655.14			

Note: Standard errors clustered at the county and cohort level are reported in parentheses. *, **, *** denote significance at the 10, 5 and 1 percent level, respectively. The dependent variable is difference in student achievement in high school and compulsory school. The variable school choice is an interaction between formal school choice and potential school choice. The model specifications are similar to the model specification in column (3) in Table 4, except as indicated.

As mentioned earlier, the main analysis excludes counties with so-called quasi-systems. To compare all the students in the data, not just those who were exposed to full formal school choice or no formal school choice, I present one specification which includes the students who lived in counties with quasi-systems. In panel A of Table 7, I have replaced the dummy variable representing formal school choice with a scale variable which takes into account all the different degrees of formal school choice. School choice will then be measured on a scale from 0 to 1, where municipalities are represented with the values of 0, 0.2, 0.5, 0.8 and 1.

As before, a value of 0 indicates no choice, and a value of 1 indicates formal school choice. Having 0.2 in formal school choice can, for example, mean that the students have to apply for the nearest school as the first choice, but can choose the second and third choice schools freely within the county. A value of 0.5 in formal school choice indicates, for example, that students could choose between the schools in the same city or municipality that they lived in. A value of 0.8 suggests that students have almost full formal school choice, but there could be a few limitations; for example, the county could be divided into two separate areas, and students can choose freely within the area where they live.

Table 7: Different sub-samples related to students' residences and timing of graduation

Panel A. Including counties with quasi-systems	All students	Boys	Girls
School choice	0.057*	0.102**	0.030
	(0.032)	(0.041)	(0.039)
Observations	67,020	26,927	40,093
Panel B. Including only students that graduated on time	All students	Boys	Girls
School choice	0.052	0.120***	0.014
	(0.034)	(0.043)	(0.043)
Observations	43,492	17,514	25,978

Note: Standard errors clustered at the county and cohort level are reported in parentheses. *, **, *** denote significance at the 10, 5 and 1 percent level, respectively. The dependent variable is difference in student achievement in high school and compulsory school. The variable school choice is an interaction between formal school choice and potential school choice. The model specifications are similar to the model specification in column (3) in Table 4, except as indicated.

As can be seen from column (1), adding those students with limited choice does not qualitatively change the result. The effect of school choice is somewhat smaller in magnitude and only significant at the 10 percent level. Looking at column (2) and (3), both coefficients for school choice are positive, but the effect is much larger and is only significant for boys. This is similar to previous results.

School choice was relatively sTable over the three years when the cohorts started high school. However, there were a few changes in 2005. Because students have a legal right to five years of high school education, students may transfer to another school or study track after one or two years of schooling. To try to address this issue, I perform an analysis including only students who finished high school within three years and graduated on time. Thus, panel B of Table 7 presents results only for the students who graduated on-time. Although the effects are less precisely estimated, the results are similar to previous regressions. Again, the effect is largest and only significant for boys.

6.2 Heterogeneity analyses

Motivated by the results in Hastings et al. (2006) finding positive effects of school choice only for students whose parents placed high weight on school test scores, I perform some heterogeneity analyses with respect to GPA level and parental education level.

To investigate possible non-linearity in the impact of choice, I split the sample into several different sub-samples. In panel A of Table 8, I exclude the best students, i.e., those who got the highest grade (6) in Norwegian at the end of compulsory education, to investigate ceiling effects.

Table 8: Different sub-samples with respect to grade level

Panel A. Excluding students with the highest grade in Norwegian from compulsory education	All students	Boys	Girls
School choice	0.068**	0.129***	0.033
	(0.033)	(0.041)	(0.042)
Observations	47,177	19,609	27,568
Panel B. Excluding students with a Norwegian grade below average from compulsory education	**All students**	**Boys**	**Girls**
School choice	0.042	0.010**	-0.004
	(0.033)	(0.041)	(0.040)
Observations	27,165	13,427	13,738
Panel C. Excluding students with a Norwegian grade above average from compulsory education	**All students**	**Boys**	**Girls**
School choice	0.054	0.088	0.046
	(0.050)	(0.067)	(0.058)
Observations	22,202	6,687	15,515

Note: Standard errors clustered at the county and cohort level are reported in parentheses. *, **, *** denote significance at the 10, 5 and 1 percent level, respectively. The dependent variable is difference in student achievement in high school and compulsory school. The variable school choice is an interaction between formal school choice and potential school choice. The model specifications are similar to the model specification in column (3) in Table 4, except as indicated.

Excluding these students does not change the results much. However, in panel B and C, I divide the sample between students with below and above average grades in Norwegian language from compulsory education. The results indicate that boys with a grade below average are most affected by school choice.

Some further heterogeneity analysis related to parental educational level and GPA level is presented in Table 9. Panel A indicates that school choice affect both boys whose parents have both low and high levels of education. In column (1) in panel B, which includes all students in the regression sample, it is not possible to identify a significant effect for any of the four GPA quartiles, except quartile 3. In column (2), on the other hand, it turns out that

boys in all quartiles, except in quartile 4, are significantly affected by school choice. Girls in all quartiles are not affected.

Table 9: Heterogeneity related to parental background and GPA level

Panel A. Effect of parental education level on school choice	All students	Boys	Girls
Low educated parents	0.095**	0.171***	0.055
	(0.044)	(0.052)	(0.049)
Observations	22,001	7,836	14,165
High educated parents	0.059	0.108**	0.024
	(0.037)	(0.047)	(0.059)
Observations	27,366	12,278	15,088
Panel B. Effect of school choice by GPA level	**All students**	**Boys**	**Girls**
GPA in quartile 1	0.079	0.123*	0.044
	(0.048)	(0.067)	(0.055)
Observations	14,036	7,083	6,953
GPA in quartile 2	0.081	0.123*	0.055
	(0.050)	(0.064)	(0.069)
Observations	12,060	5,317	6,743
GPA in quartile 3	0.085*	0.200**	0.043
	(0.048)	(0.083)	(0.062)
Observations	13,560	4,887	8,673
GPA in quartile 4	0.010	-0.005	0.014
	(0.068)	(0.085)	(0.072)
Observations	9,711	2,827	6,884

Note: Standard errors clustered at the county and cohort level are reported in parentheses. *, **, *** denote significance at the 10, 5 and 1 percent level, respectively. The dependent variable is difference in student achievement in high school and compulsory school. The variable school choice is an interaction between formal school choice and potential school choice. The model specifications are similar to the model specification in column (3) in Table 4, except as indicated.

6.3 Other educational outcomes

In Table 10, I look at other educational outcomes, which is graduation from high school and enrollment in higher education. Panel A includes a larger sample size, due to the fact that I have included both those who graduated from a vocational study track and those who did not graduate at all. Panel B consists of the same regression sample as previously used. The estimation model is no longer a difference-in-differences-in-differences specification, but the

grade in Norwegian from compulsory education is included as a right-hand side variable to control for previous skills in both panels.

Table 10: Graduation from high school and university attainment as outcome variables

Panel A. Graduated from high school	All students	Boys	Girls
School choice	0.0197*	0.0223	0.0175
	(0.0113)	(0.0141)	(0.0113)
Observations	113,204	57,648	55,556
Panel B. Higher education	All students	Boys	Girls
School choice	0.0399***	0.0372*	0.0407***
	(0.0105)	(0.0220)	(0.0125)
Observations	49,367	20,114	29,253

Note: Standard errors clustered at the county and cohort level are reported in parentheses. *, **, *** denote significance at the 10, 5 and 1 percent level, respectively. The dependent variable is difference in student achievement in high school and compulsory school. The variable school choice is an interaction between formal school choice and potential school choice. The model specifications are similar to the model specification in column (3) in Table 4, except as indicated.

School choice increases the probability of graduating from high school (panel A). The effect is positive as expected, but significant only at the 10 percent level. In addition, the gender results from previous regressions are not replicated in Table 10. Column (2) and (3) of panel A indicate no difference in the effect on graduation for boys and girls.

Focusing on panel B, column (1) finds a positive effect of school choice on the probability of enrolling in higher education within five years of the completion of compulsory education. However, this effect is also smaller in magnitude compared to the effect on student achievement, but slightly larger than the effect in panel A. However, column (2) and (3) in this panel indicates a much larger and significant effect for girls compared to previous results.

7. Conclusion

In this paper, I have investigated the effect of school choice in post-compulsory high school education on student performance using a difference-in-differences-in-differences model specification. The results indicate a positive and significant effect on student achievement.

However, splitting the sample by gender indicates that boys respond more to choice than girls. For boys, school choice increases student achievement by about 0.12 percent of a standard deviation. This result is robust to a range of different model specifications. In addition, school choice seems to increase graduation rates in high school and enrollment in higher education. It is possible to think of several mechanisms through which choice effects could work.

These results are consistent with school choice increasing competition between schools in order to attract the best students. The schools' reputation, which could be viewed as a competition parameter for the schools, arguably depends on the students attending the school today. Hence, the schools may introduce policies to try to increase the performance of their current students, in order to attract good students in the future. From my results, it seems that these possible school policies affect boys to a larger degree than girls. This could explain the differing results of school choice on achievement for boys and girls. In addition, while the threat of school closings and firing of teachers is not common in the public school system in Norway, teacher quality could be affected. Schools could possible pay closer attention to teacher quality in their hiring processes. They may view this as a possible way to increase student achievement. The schools arguably have many instruments to affect student behavior and effort, but this analysis cannot reveal how school behavior changes.

Some earlier papers (e.g., Figlio and Hart, 2010) argue that public schools are motivated by competition for funding. If they perform badly, student enrollment will probably decrease, as will funding, since funds are connected to student enrollment. This connection between student enrollment and funding is less obvious in the Norwegian school system. An example is small schools which receives additional funding per student, compared to urban schools. Funding is probably more closely related to student enrollment in a system with a larger density of private schools, where students pay tuition.

Another aspect of the competition argument is teacher sorting. Empirical papers using Norwegian data find that teachers tend to leave schools with a high share of minority students and low student performance.[14] Thus, school choice could lead to competition between schools because they strive to achieve high student performance in order to attract the best teachers.

[14] See Falch and Strøm (2004) and Falch and Rønning (2007).

Another possible effect of school choice is student composition effects. Hsieh and Urquiola (2006) suggest that the choice reform in Chile led to cream-skimming. If school choice changes the composition of students and peer effects are important – for example if high achieving students applied to schools in school choice counties – this could affect the estimates, because better students were attending schools subject to school choice. However, this should not happen in Norway, since students have to apply for a high school in their county of residence. As a result, there should be few peer effects leaking to other counties. Further evidence on explicit mechanisms leading to choice effects on achievement is left for further research.

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Appendix Tables

Appendix Table A1: Data reduction

	Observations	Percent of population
Total population. All students graduating from compulsory education in 2002-2004	174,067	100
Didn't finish an academic study track	98,492	56.6
Not 16 when finishing compulsory education	1,374	0.8
Missing grade information	375	0.22
Missing school owner status	2,509	1.44
Enrolled in a private high school	3,400	1.95
Missing choice information	692	0.40
Missing parents marital status	3	0.002
Counties with quasi-systems	17,705	10.17
Students that completed the high school exam in Norwegian more than five years after compulsory education	150	0.086
Regression sample	49,367	28.33

Appendix Table A2: Descriptive statistics

	Regression sample	
	Mean	Standard deviation
Girl	0.593	
First generation immigrant	0.022	
Second generation immigrant	0.021	
Both parents have compulsory education only	0.074	
At least one parent has a high school education	0.372	
At least one parent has a bachelor's degree	0.376	
At least one parent has a master's or doctoral degree	0.178	
Benefits due to disabilities or diseases	0.015	
Benefits due to private nursing or care	0.016	
Birth month	6.398	3.353
Parents married	0.698	
Parents divorced	0.112	
Parents never married	0.188	
Parental income in quartile 1	0.213	
Parental income in quartile 2	0.241	
Parental income in quartile 3	0.258	
Parental income in quartile 4	0.288	
Both parents employed	0.777	
Only mother employed	0.085	
Only father employed	0.110	
Birth year 1986	0.322	
Birth year 1987	0.332	
Birth year 1988	0.346	
Number of students at the compulsory school	48.75	27.34
Observations	49,367	

*In the regression sample, counties with different degrees of choice within the county are excluded.

Appendix Table A3: Full results for the regressions in column (1)-(3) in Table 4

	(1)	(2)	(3)
Formal school choice	-0.021		
	(0.035)		
Potential school choice	0.050	0.050*	-0.004
	(0.031)	(0.028)	(0.024)
School choice	0.132***	0.090**	0.073**
	(0.045)	(0.039)	(0.033)
Girl			-0.200***
			(0.009)
First generation immigrants			0.130***
			(0.034)
Second generation immigrants			0.105***
			(0.037)
At least one parent have a high school education			0.003
			(0.019)
At least one parent has a bachelor's degree			0.019
			(0.017)
At least one parent has a master's or doctoral degree			0.095***
			(0.020)
Benefits due to disabilities or diseases			-0.014
			(0.041)
Benefits due to private nursing or care			0.095**
			(0.036)
Birth month			0.009***
			(0.001)
Married parents			0.0006
			(0.0104)
Divorced parents			0.003
			(0.018)
Both parents employed			-0.021
			(0.024)
Only father employed			-0.022
			(0.025)
Only mother employed			-0.019
			(0.025)
Parental income in quartile 2			-0.018
			(0.015)
Parental income in quartile 3			-0.030**
			(0.012)
Parental income in quartile 4			0.005
			(0.014)
Number of students at the compulsory school			0.0027***
			(0.0002)
Observations	49,367	49,367	49,367

Note: Standard errors clustered at the county and cohort level are reported in parentheses. *, **, *** denote significance at the 10, 5 and 1 percent level, respectively. The dependent variable is difference in student achievement in high school and compulsory school. The variable school choice is an interaction between formal school choice and potential school choice.