Gender peer effects on further education

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This paper studies the relationship between gender peers in school and further education. I use detailed Norwegian register data to estimate the influence of the proportion of girls in the last grade of compulsory school on different educational outcomes, including high school education and university attainment. A higher proportion of girls lead to both higher probability of graduating from high school and being enrolled in higher education five years later. The results are robust to several model specifications. Heterogeneity analyses show that the relationship between the peer measure and the educational variables are driven by individuals in the middle of the ability distribution, measured by grade point average (GPA), from compulsory education. This suggests that gender peer effects are most important for students that are most likely to be on the margin of graduation and enrolling in higher education.

June 2012

1. Introduction

In which way do people around you affect your life? This question concerning peer effects has received increased attention in economics of education literature over the last decade.[1] Defining if peer effects exist is of great interests to both policy makers and scientists. By identifying factors that increase the probability of youths graduating from high school, and thereby succeed in the labor market, one may be able to prevent them from becoming unemployed or even criminals. This could result in a large gain for society both in terms of increased tax revenues, and reduced resource demand by the criminal justice system.

Theory models suggest that students are influenced by their peers. An example is Lazear (2001), who models classroom education as a public good, which is subject to congestion effects. These congestion effects can take place in the form of students with bad behaviour disrupting teaching. In turn this creates negative externalities that harm other students. A big empirical challenge when analyzing peer effects is separating a group's influence on an individual's outcome from the individual's influence on the group, the so-called reflection problem, (Manski, 1993, and Vigdor and Nechyba, 2007). Having detailed Norwegian register data, I address this problem by using an exogenous characteristic, gender, as the peer variable. More specific, I examine the effect of the proportion of girls in the last grade of compulsory education on several different educational outcomes, with main focus on high school education. After compulsory education, Norwegian 16-year olds select themselves to different high schools. As a result I exploit the fact that the peer measure is both lagged, since the outcome variables are measured after compulsory education, and only weakly correlated to the students' current peer group. I will also look at the students' probability of attending higher education.

There are several difficulties in identifying peer effects. As mentioned above the reflection problem is a challenge I address in several ways. Second, parents and students usually select themselves into different neighbourhoods and groups respectively. Vigdor and Nechyba (2007) argue that if unobservable higher achieving students select themselves into higher achieving peer groups, the estimated results will include a positive selection bias.

[1] See for example Hoxby (2000), Sacerdote (2001), Zimmerman, (2003) and Lavy and Schlosser (2011).

I will follow the identification strategy presented by Hoxby (2000), and use variation in gender composition in a grade over adjacent cohorts within the same school as the peer variable. As argued by Hoxby (2000) this approach is less vulnerable to selection bias than more traditional measures of achievement. Clearly, there might also be selection problems regarding the proportion of females in high school grades, since students sort themselves to different high schools. I address these possible selection problems in numerous ways. First, I follow Hanushek et al. (2003) and Vigdor and Nechyba (2007) and use the proportion of females in the last grade (10th grade) of compulsory education. This is assumed to be random over adjacent cohorts since public schools use specific neighbourhood catchment areas. Second, the peer variable is measured at the grade level, and not classroom level to avoid problems with within school sorting. This is similar to Lavy and Schlosser (2011). Third, I instrument the proportion of girls at the school level with the proportion of girls at the municipality level, to account for possible sorting between schools within a municipality. Finally, I include GPA as a control variable. Since girls tend to perform better than boys in school, GPA might be an important control variable.

When estimating peer effects based on the proportion of females in a grade, the question of sufficient variation is of great importance. Norwegian compulsory education consists of several small schools, which contribute to variation in the proportion of female students due to the law of large numbers. In small schools, however, students of different ages could be put into one common class, so-called grade mixing. To account for the potential problem of grade mixing, I perform a robustness check where small schools, that are candidates for grade mixing, are excluded. This does not affect the result qualitatively.

The dataset contains the three cohorts who finished compulsory education in 2002, 2003 and 2004. Individual- and family characteristics as well as GPA from compulsory education are available for all these students, and I am able to follow them for five years after the completion of compulsory education. By including school fixed effects I can control for unobservable school factors. I also perform heterogeneity analyses related to gender, GPA level and student background. The estimated results show a significant and positive peer effect on high school graduation and attending higher education five years after the completion of compulsory education. Girls and students with highly educated parents benefit the most from having female peers, both in terms of graduating from high school and the probability of being enrolled in higher education five years after compulsory education.

The paper is organized as follows: Section 2 gives an overview of previous literature, while section 3 presents the relevant institutions. Section 4 discusses the identification strategy and summarizes the data. Section 5 presents the results, while section 6 includes some robustness analyses. Section 7 concludes.

2. Literature review

Due to the potential selection problems discussed above, some papers have based their analysis on, what they claim to be, randomly assigned peer groups. Sacerdote (2001) and Zimmerman (2003) use random assignment of roommates in different colleges to study how roommates affect student outcomes. Sacerdote (2001) finds that roommates affect freshman year GPA and the decision to join a fraternity or sorority. Zimmerman (2003) estimates some small negative effects on GPA for students with middle SAT verbal score, who is living together with students with low SAT verbal score.

Carrell et al. (2009) argues that a student's roommate is only a small part of that student's peer group. This indicates that previous effects (Sacerdote, 2001, and Zimmerman, 2003) may be underestimated. In their paper, Carell et al. (2009) analyze peer effects based on a sample where students are randomly assigned to groups of 30, at the United States Air Force Academy. The students have limited possibilities to interact with other students during their freshman year. The results show that peer effects measured at the roommate or dorm floor level is much smaller, than those estimated with the groups of 30 students as the peer group.

Duflo et al. (2008) use experimental data from Kenya to analyze the effect of tracking on student performance. After receiving funding for an additional first grade teacher, about 50 percent of the schools in the sample, split their students randomly into two sections. The other half assigned students to sections based on their previous achievement. Duflo et al. (2008) find that tracking benefitted all of the students, also those assigned to lower achieving peers. They argue that the result is probably due to teachers adapting to the academic level in the group.

Many peer studies examine the effect on elementary school students´ test scores. Examples include Ammermueller and Pischke (2006), Angrist and Lang (2004), Hanushek et al. (2003) and Vigdor and Nechyba (2007). The results of these analyses are mixed. While the three former claims to have found peer effects, Vigdor and Nechyba (2007) are critical to the results from their basic OLS regressions. By performing three empirical tests, they rejects that the correlation between student achievement and peer characteristics can be subject to a causal interpretation.

It is suggested in theory models that high ability students create positive spillover effects onto other students (e.g., Epple and Romano, 1998). Empirical research in this area includes Gould et al. (2009), and Lavy et al. (2009). Both papers find negative effects of low ability students, repeaters (Lavy et al., 2009) and immigrants (Gould et al., 2009), on regular and native students´ school performance respectively.

Most studies concerning peer effects focus on student test score as the outcome variable, but some papers have explored other issues. Evans et al. (1992) look at how peer groups affect teenage pregnancy and school dropout behaviour. When they treat their peer measure as an endogenous variable, they find no effect on either outcome. Bifulco et al. (2009) investigates the effects of percent minorities and percent with college educated mothers in the cohort. They find that higher levels of parent education, in the cohort, decrease the likelihood of high school dropout and the use of marijuana after high school, and increase the likelihood of college attendance.

As seen above, there is a large literature analyzing peer effects, but there exists several challenges regarding identification. As a result Hoxby (2000) uses sources of variation that she argues are credibly idiosyncratic. One of her peer measures is changes in the gender composition of a grade in a school in adjacent cohorts. By following Hoxby (2000), and using proportion of girls as the peer variable, I am able to obtain more credible identification of one specific peer group effect. In addition, Lavy and Schlosser (2011) argues that the social interactions between genders play an important role in academic achievement. This encourages studies of gender peer effects as an interesting topic. Hoxby (2000) identifies both gender and race peer effects in Texas elementary schools. The results show that an increase in the proportion of females in the classroom, leads to higher test scores in math for both males and females. Another analysis concerning gender peer effects is Whitmore (2005), who use data from the Tennessee STAR project. Her results indicate that girls have a positive spillover effect onto both boys' and other girls' test scores in early grades.

Lavy and Schlosser (2011) study gender peer effects in Israeli primary, middle and high schools. The results show that an increase in the proportion of girls has a positive effect on academic achievement for both boys and girls. Using additional survey information, they are able to identify some potential mechanisms that peer effects might work through. A higher proportion of girls in the classroom contribute to lower levels of classroom disruption and violence, improved inter-student and student-teacher relationships, and it lessens teachers' fatigue. Oosterbeek and van Ewijk (2010) is a recent analysis that study gender peer effects in higher education. They do not find substantial effects on student performance.

A recent paper by Black et al. (2010) use Norwegian data to analyze peer influence on several long-term outcomes. They use several methods to estimate the effect of different peer measures, including gender composition in a grade. Their dataset consists of Norwegian cohorts born between 1959 and 1973, and the only peer measure for which they find any effect is the proportion of female students. The present paper deviates from Black et al. (2010) in several important ways. First, I will focus more narrowly on educational outcomes as completion of high school and enrolment in higher education. Second, I address the potential problem of grade mixing in Norwegian schools. Third, by estimating models conditional on student GPA from compulsory school, I am able to investigate whether gender composition has long term effects beyond the possible short-run impact on performance in compulsory school. This is an important feature since the proportion of girls and GPA are correlated in Norwegian data. In the regression sample girls outperform boys in all subjects except physical education. Fourth, by considering the cohorts born in 1986-1988 I investigate educational outcomes after the major reform taking place in the Norwegian high school system in 1994, and thus consider effects within a fairly stable institutional setting. Further, the focus on the recent cohorts should be most informative of the peer group effects most relevant for the present school system.

3. Institutions

Compulsory education in Norway consists of 10 years of schooling. From age seven, children first attend six years of elementary school and then three years of junior high school.[2] The school system is relatively homogenous. Less than two percent of all students attend a private compulsory school.[3] Public schools practice catchment areas, and are single-sex schools only to the extent that the catchment area includes only one gender in the relevant age groups. In 1923 the Norwegian government passed a law saying that it would not financially support municipalities where schools did not offer the same opportunities to all students. Today, there exists relatively few private schools, but to be entitled to public financial support they have to follow the same laws as public schools which say that the schools have to be open for students of both genders. There is no reason to believe that one gender choose to go to private school to a greater extent than the other.[4] As a result this should not create a bias in gender variation in public schools, in areas with a concentration of private schools.

Another favourable feature concerning the Norwegian school system is the classroom structure. Students are usually in the same classroom the whole day with the same peers, while teachers move from classroom to classroom with different subjects (Black et al., 2010). Everybody graduates from compulsory school at the end of 10th grade, grade repetition is basically non-existing (Strøm, 2004). The students receive a diploma containing 13 grades in different subjects on a scale from one (lowest) to six (highest), set by teachers.[5] It is not possible to fail a subject. In addition, there is a final written exit exam in Norwegian language, English language or mathematics. 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.

[2] Some students started school at age six, due to early implementation of a compulsory school reform increasing compulsory schooling by one year.
[3] Private compulsory schools are mainly Christian schools or schools with an alternative pedagogical approach.
[4] In 2002 47.7 percent of the students at private schools were boys, and 52.3 percent were girls. These numbers are stable during the empirical period.
[5] 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 it is not considered mature enough. This decision is made by the parents together with the school and psychologists.

Municipalities are responsible for providing compulsory education. Compulsory schools are free of charge, and tracking of students by ability is not allowed according to the Norwegian Education Act, § 8-2. Students are allocated to elementary and junior high schools based on fixed neighbourhood catchment areas. School enrollment strictly follows these catchment areas, which implies that parental school choice between schools for given residence is not allowed (Black et al., 2010, Leuven and Rønning, 2011). Norway is characterized by relatively little student mobility (Bonesrønning and Vaag Iversen, 2011). Casual evidence indicates that most students spend all three years of junior high at the same school.

Very small schools were until 2003 subject to a grade mixing rule. This rule stated that if there were less than 18 students at a junior high school, the three grades (8th grade through 10th grade) could be taught in the same classroom. In the same way, when the combined enrollment of two adjacent cohorts did not exceed 24 students, the two grades could be taught in the same classroom (Norwegian Education Act, § 8-3). On one hand, including small schools offer more variation in the variable of interest, but on the other hand, they introduce a measurement problem because of potential grade mixing. I address this issue below.

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. Some of these study tracks are heavily dominated by one gender. An example is the study track of health and social work where over 90 percent of the students are females. The general academic study track is the largest track and includes about 40 percent of enrolled students.

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) form compulsory education. All students have a legal right to complete high school, but it has to be within a time frame of five years.[6] Therefore I follow the students for five years after compulsory education.

4. Identification strategy and the data

4.1 Identification strategy

As mentioned, there are two main challenges when trying to identify peer effects. Selection problems occur because parents and students sort themselves into neighborhoods and peer groups respectively. To deal with the possible selection bias, researchers have tried to apply natural experiments in their analysis. As the current data set consists of observational data, I use the identification strategy of Hoxby (2000) in the present paper. I investigate how variation in the proportion of girls in a grade, over adjacent cohorts within the same school, affects the chosen outcomes. The Norwegian school system provides some preferable features for conducting such an analysis. Grade repetition is basically non-existing (Strøm, 2004). This makes variation in the proportion of girls over adjacent cohorts more reliable, since it is not influenced by students repeating a grade. Only a small proportion of Norwegian students go to private schools. In addition, since public schools use catchment areas, it is difficult for parents and school leaders to manipulate the proportion of girls in a grade. It would also seem unlikely that the proportion of girls is a factor that parents and students select themselves after.

As pointed out above the proportion of girls in a class will probably be highly correlated with the proportion of girls in a grade. As a result, the proportion of girls in a grade should be representative for classroom gender composition. In addition, by using the grade level I can prevent biased results due to possible student and teacher sorting within the grade. Another way of controlling for sorting and selection is through fixed effects strategies and school specific time trends. Vigdor and Nechyba (2007) are able to include both school and teacher fixed effects to control for sorting both into and within schools. Black et al. (2010), Lavy and Schlosser (2011) and Haraldsvik and Bonesrønning (2011) include school specific time trends in addition to school fixed effects.

[6] There is an option for students to apply for a transfer to another study track or school.

Hoxby (2000) argues that the variation in gender is credibly idiosyncratic. To investigate this in the present data I have estimated the peer measure against each control variable. This is presented in column (1) in appendix table A2. Each row in column (1) represents a separate regression for the proportion of girls at school. The correlations with GPA and the dummy variable for gender are highly significant. Regarding the dummy variable for gender, there is a correlation by definition since it has to be more common to be a girl in schools with a high proportion of girls than in other schools. Regarding both the gender variable and GPA, the table show a negative correlation with the peer measure. This is due to the construction of the peer variable. When constructing the proportion of girls variable I excluded the specific student from the peer group. This will make the respective peer group different for boys and girls. When estimating a regression with just the proportion of girls without excluding the specific student there is a positive significant correlation between both the gender variable and the proportion of girls and GPA and proportion of girls. The same results are found for most countries on international comparable tests.[7] For the other variables included in the present analysis, the correlation with the proportion of girls at schools is not significant at the 10 percent level with the exception of the dummy variables for first generation immigrant and the year 2003.

In column (2) all control variables are included in the same regression, except the indicator for gender. GPA is still highly significant, and there is joint significance with an F-value of 4.39. When excluding GPA from the regression in column (3), the other variables are not jointly significant at conventional levels with an F-value of 1.24. This further supports the argument that gender variation is idiosyncratic, with the exception of GPA.

Another issue is the reflection problem, as formulated by Manski (1993). There is simultaneity in the determination of peer effects, because it is hard to separate the influence of the peer group on the student, from the influence of the student on the peer group. Both Vigdor and Nechyba (2007) and Hanushek et al. (2003) use lagged peer outcome measures to circumvent the reflection problem. Carrell et al. (2009) criticize this approach by claiming that the peers in a student’s current peer group were also likely to have been his/hers peers in the previous period. It is a high correlation in peer group across years. This is not the case in

[7] See for example Machin and Pekkarinen (2008) and Machin and McNally (2005).

the present data since the students change schools from compulsory education to high schools. Since students choose different high school study tracks after compulsory school, and are separated to different schools, the peer group in high school is only weakly correlated with the peer group from compulsory school. The correlation between the proportion of girls in compulsory school and in high school the next school year equals 0.05. With the combination of using plausibly exogenous variation in gender and the lagged gender composition as a peer variable, I am able to address both the selection problem and the reflection problem.

4.2 Model specification

Using the three cohorts of students that completed compulsory education in the years 2002-2004, I estimate the effect of proportion of females (P) on several different outcome variables (y) for student i in school s. The general regression is showed in equation (1).

$$(1)\quad y_{is} = \beta_0 + \beta_1 P_{i-1,s} + \beta_2 GPA_{is} + X_{is}\beta_3 + u_{is}$$

As control variables I include a set of individual and family characteristics. The vector X include gender, immigration status, parental education, parental income, parental labor market status and marital status, month of birth, public benefits before age 18 related to disabilities, and the number of students at the junior high school the student graduated from.

I will perform several robustness analyses. First, omitted variables may be a source of bias. By including fixed school effects I am able to control for unobservable school factors. Following Lavy and Schlosser (2010), I also include school specific time trends to control for additional omitted factors.

One concern for the identification of peer effects is that the variation may be too low to identify an effect. Especially in large schools, the proportion of girls will probably be approximately 50 percent in most cohorts. So the variation in the proportion of girls may, in most cases, reflect the variation in the proportion of girls in small schools. This may potentially reduce the external validity of my results. In addition, there is a more serious concern. In small junior high schools, that was subject to grade mixing, the variation in the proportion of girls in a grade may not reflect the true variation. The variation may not originate from variation in the gender distribution in different grades, but instead from the grade mixing rule. To address these problems I will perform a robustness check estimating the model on different subsamples. First, excluding all schools with less than 24 students in 10th grade, certainly no school in the sample has grade mixing. However, since the variation in cohort size is limited, schools with more than 15 students in the final grade do neither in practice have grade mixing. If the results do not change much when excluding these small schools, then it is probably not the variation in small schools or grade mixing that generates the results.

It is a possibility that the proportion of girls in a grade may be endogenous. This is not a very plausible scenario, but it could be that parents believe that attending a class with a high proportion of girls benefits their children, and thereby sort themselves to these schools. This could lead to a simultaneity bias in the estimation. Even though this is unlikely I try to control for this possible problem by instrumenting the proportion of girls at the grade level with the proportion of girls at the municipality level. This variable is believed to be correlated with the proportion of girls at the grade levels at the specific schools, but it is not believed to be correlated with any observable factors that may also affect the chosen outcomes.

Previous analysis (e.g Black et al. 2010) has included the average peer characteristics in the model. I have also estimated a regression that includes all of the control variables calculated for the peers. In this way, I can investigate to what extent the effect of gender composition is robust to the inclusion of other types of peer effects.

4.3 Data and descriptive statistics

The student data, including family- and individual characteristics, and grade information, 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 school identifiers for both the compulsory school they graduated from, and the high school in which they enrolled. I limit the sample to normal-aged individuals i.e. those who turned 16 in the year they started high school. Details on data reduction are showed in appendix table A1. As can be seen from this table, limiting the sample to normal-aged individuals reduces the sample with almost six percent. About

3,400 individuals (1.94 percent) are missing grade information. A total of 7.8 percent of the population is excluded from the regression sample.

The educational outcomes

I will estimate the effect of several different educational outcomes. I will examine these outcomes: High school graduation, choice of high school study track and enrolment in higher education. The main outcome is high school graduation. The graduation variable is a dummy variable equal to 1 if the student graduated from high school within five years after the completion of compulsory education. About 69 percent of the regression sample graduated from high school within five years. This indicates that there is a serious dropout problem in Norwegian high schools. Full descriptive statistics is showed in table 1.

Following Black et al. (2010), I also look at the choice of high school study track. This includes two binary variables defining if the student started an academic or a vocational study track. Table 1 show that 45.6 percent started an academic study track right after compulsory education, while 51.1 percent started a vocational study track. 3.3 percent did not start high school in the fall following the completion of compulsory education.

Finally, I examine university attainment. The outcome variable is a binary variable equal to 1 if the student is reported as being enrolled in higher education in the fall five years after the completion of compulsory education. So, there is a long time spell from the peer influence and the measuring of the outcome variable. Out of the regression sample, 36 percent were enrolled in higher education five years after the completion of compulsory education.

The peer variable

The main independent variable is the peer measure. It is constructed as the proportion of girls at the grade level in 10th grade. I use the proportion of girls in a grade as opposed to in a class. This is partly due to restrictions in the data, but the specification does offer some positive features as well. The specific individual is removed, as to represent the peer group accurately. This indicates that the peer group will be slightly different for boys and girls. The mean proportion of girls is 48.8 percent for the whole sample. In small schools the mean proportion of girls is 47.9 percent (not shown in table), and the standard deviation is higher, indicating more variation in the proportion of girls in small schools. This is supported by figure 1 that shows the variation in the proportion of girls in small and large schools respectively. It is clearly more variation in the proportion of girls in small schools.

Control variables

I include the average grade point from compulsory education (GPA) as a measure of prior achievement. This is an important variable since achievement may be highly correlated with completed education. Failure to include GPA in the regression may lead to ability bias in the estimates since those with high skills are more likely to complete more education. GPA is also likely to be correlated with other variables like parental education. In addition, GPA and gender are correlated in Norwegian data. Girls tend to outperform boys in most subjects in compulsory school. Without controlling for GPA, the correlation between these other variables and GPA could have biased the peer variable. GPA is measured on a scale from 1 (lowest) to 6 (highest). Mean GPA is 3.96, and the standard deviation is 0.83. In addition, I include a wide range of individual- and family characteristics. These characteristics include gender, immigration status, birth month, two health variables, parents' education level, income level, employment status and their marital status. In addition, I include the number of students at the compulsory school the student attended as a control for school factors.

There are 3.6 percent first generation immigrants in the sample, and two percent second generation immigrants. Benefits due to disabilities or diseases before the age of 18 are received by two percent, while 2.8 percent have received benefits to support needs for private nursing or care. 14.7 percent of the students have parents with compulsory school only, while almost 40 percent have parents with higher education (bachelor degree or higher). 60.6 percent of the individuals have married parents, 12.6 percent have divorced parents, and 28.6 percent have not been married. The students are pretty evenly distributed over the three cohorts.

5. Results

Table 2 presents results from simple OLS regressions using graduation, the choice of high school study track, and the probability of attending higher education as outcome variables. When increasing the proportion of girls by 10 percentage points the probability of completing high school within five years of compulsory education increases with 0.49 percentage points. The effect is significant at conventional levels. To put this perspective, having an all female class would increase the probability of completing high school with almost 5 percentage point. This could be compared to the matriculation outcome in Lavy and Schlosser (2011). The magnitude of the effects is slightly lower than their result. There is a positive and highly significant effect of GPA on graduation.

Increasing the proportion of girls affects the choice of an academic study track negatively, and the choice of a vocational track positively. However, the effects are much smaller in magnitude and none of the results are significant. This topic is also analyzed in Black et al. (2010). They find that a higher proportion of girls make boys less likely to choose an academic study track. When looking at the effect of choice of study track for each gender, I still find no significant results (not reported in table). So the findings of Black et al. (2010) are not replicated in these data. This could be due to the fact that the present study analyzes more recent data, and very few individuals dropped out after compulsory education.[8] On the contrary, the probability of being enrolled in higher education is significantly increased with a higher proportion of girls in the compulsory school grade. Increasing the proportion of girls with 10 percentage points leads to 0.32 percentage points increase in the probability of attending higher education five years after completed compulsory education.

Regarding gender, column (1) shows that girls are estimated to have a 2.5 percentage point lower probability of graduating. This result is due to the fact that gender is correlated with GPA. When removing GPA from the regression, girls have a statistically significant higher probability of graduation from high school. Married parents, parental employment and high parental education and income also contribute positively to both the completion of high school, and the probability of being enrolled in higher education.

As mentioned above, selection problems may bias the results due to the fact that parents and students sort themselves into specific peer groups. In an attempt to control for this I include

[8] Excluding the individuals that did not start high school from the analysis do not change the results. I have also estimated a multinomial logit specification with the three outcomes being started an academic study track, started a vocational study track and did not start high school in the fall following the completion of compulsory education. This analysis is performed without fixed effects, as this did not affect the results much in the OLS models. This analysis show very similar results.

school fixed effects in the regression, presented in table 3. The effect of the peer variable on the choice of study track in high school does not change much. Both results in column (2) and (3) are still insignificant and the magnitudes of the coefficients are only slightly reduced compared to previous results. Regarding high school graduation the effect of the peer variable actually increases. A 10 percentage points increase in the proportion of girls now raise probability of completing high school (within five years of completed compulsory education) with 0.56 percentage points. The effect on higher education is also increased, and both estimates are now highly significant. From these fixed effects estimations it does not appear to be a selection problem regarding schools.

6. Robustness analyses and heterogeneity

6.1 Robustness analyses

I then perform some robustness checks to address potential estimation problems. I focus on the outcome variables which seem to be significantly affected by the gender peer measure. To address the problem concerning grade mixing I exclude small schools that were candidates for grade mixing. All schools that had less than 24 students in the 10th grade are removed from the sample. Due to the construction of the grade mixing rule, by excluding these schools all possibilities of grade mixing is eliminated.[9] I also look at a specification where only the schools with less than 15 students are excluded. These are the smallest schools and the most likely candidates for grade mixing.[10]

The results are presented in panel A, graduation from high school, and panel B, higher education, of table 4. Column (1) of the two panels is just two reference regression equal to those of column (1) and column (4) of table 3. In column (2) schools with less than 24 students are excluded, reducing the sample to 148 051 observations. This leads to an increase in the magnitude of the peer estimate for both outcomes, and it is still highly significant. In column (3) schools with less than 15 students are excluded. These regressions lead to similar results. The estimation indicates that small schools, either they are subject to grade mixing or not, do not bias the result upwards.

[9] I keep all three cohorts in these reduced sample regressions, even though the law of grade mixing was abolished before the 2003/2004 school year. Schools are typically organized in the same way for the 2004 cohort as well. I have performed regressions excluding the 2004 cohort (not reported). This does not affect the results much.

[10] The cutoff at 15 students is random. Excluding schools with from 16 to 23 schools all yield similar results.

The proportion of girls can be subject to selection problems if parents actively sort themselves and their children into school catchment areas based on this measure. To address this problem I have instrumented the proportion of girls at the compulsory school level with the proportion of girls at the municipality level. The reduced form regressions are reported in column (1) and column (2) of Table 5. The common first stage regression in column (3) shows that the proportion of girls at the municipality level is a strong instrument, with a very high F-value. The second stage regression for high school graduation and higher education are shown in column (4) and column (5) respectively. In both second stage regressions the magnitudes of the peer effects exceed those in the baseline regressions in Table 3, especially the higher education estimate.

There is some evidence that grading practices vary across teachers, see for example Figlio and Lucas (2004) and Bonesrønning (2004). This indicates that GPA measures skills with some error. In addition, behavioral aspects of the students may influence the grades, in particular in more practical subjects such as music and physical education. In Table 6, I instrument GPA using the grades from the external exit exam at the end of compulsory education. The results of the IV regressions in column (4) and (5) again show a larger effect of the peer measure relative to earlier regressions in table 3. Both IV specifications, in Table 5 and Table 6, indicate that the baseline regressions do not overestimate the results.

I have argued that GPA is an important variable. As mentioned, the data show that girls perform better than boys in most subjects, and this could lead to overestimation of the peer variable if GPA is not included in the regression. In column (1) and (2) of Table 7 I have estimated two regressions excluding GPA as a control variable. The estimated coefficients are 36 and 25 percent lower compared to the coefficients on high school graduation and higher education in Table 3 respectively. Column (3) and column (4) of Table 7 show regressions including school specific time trends. While the effect of high school graduation is similar to the baseline regression results in Table 3, the effect of on higher education is heavily reduced and turns insignificant. Black et al. (2010) estimate a regression including other peer characteristics. In the last two columns of Table 7 I have included peer characteristics for all control variables. The magnitude of the gender peer variable increases with the inclusion of these variables, and this evidence further supports that the baseline regression does not overestimate the results.

6.2 Heterogeneity analyses

To examine how the gender peer variable affects different sub groups I have performed several heterogeneity analyses. Results for different genders and parental education are reported in Table 8, and for GPA in Table 9. Panel A, of table 9, presents the results for high school graduation, and panel B for the higher education variable, in both tables. Regarding gender differences, girls seem to be positively affected by girl peers in terms of both outcome variables. Boys benefit from a higher proportion of girls when looking at the probability of graduating from high school only. Both students with highly and low educated parents benefit significantly from increasing the proportion of girls regarding the probability of graduating from high school. However, only students with highly educated parents have a higher probability of being enrolled in higher education five years after compulsory education.

In Table 9 students are divided into four quartiles based on their GPA from compulsory education. When splitting the individuals based on their GPA, I find that proportion of girls positively affect individuals with a GPA in quartile 2 in terms of high school education. Only those individuals with a GPA in quartile 3 are affected in terms of university attainment. Students in the upper part of the ability distribution are likely to graduate anyway, while students in the lower part of the ability distribution are highly likely to drop out, independent of the proportion of girl in the class. So Table 9 shows suggests that gender peer effects are most important for students that are most likely to be on the margin of graduation and enrolling in higher education.

7. Conclusion

In this paper I estimate gender peer effects. By using detailed Norwegian data I find that increasing the proportion of girls in the last grade of compulsory education increases the probability of graduation from high school, and being enrolled in higher education five years after the completion of compulsory education. By using a lagged peer measure that is both based on strict catchment areas, and only weakly correlated to the present peer group, I am able to address two of the main empirical challenges in peer effect estimations. In addition, I perform several robustness checks. These analyses indicate that the proportion of girls is idiosyncratic, and that simple relationships are not overestimated.

The evidence provided in this paper suggests that both boys and girls benefit from a higher probability of females in the classroom, in terms of high school graduation. The heterogeneity analyses also show that it is mainly students with an intermediate GPA that are affected by female peers. This could indicate that most of the individuals with a high GPA (quartile 4) will graduate, while most of those with a low GPA (quartile 1) will not graduate, independently of the number of girl peers.

Unfortunately, the data available in this study cannot be used to formally distinguish between different mechanisms leading to the results. Numerous theory models try to explain how peer effects may influence individual outcomes.[11] One way that the proportion of girls could affect these outcomes is through positive spillover of academic achievement. However, I control for GPA in the present analyses, and the results still holds. Another theory, called the bad apple model, states that if one student make a lot of noise and disrupts teaching this could hurt other students. If boys are "bad apples" to a larger degree than girls, this is a possible mechanism for the positive gender peer effects. Lavy and Schlosser (2011) conducts a survey that supports this argument. They find that the proportion of girls in a class leads to better classroom and learning environment.

However, the main purpose of this paper was to investigate if gender peer effects influence high school education and enrollment in higher education, and investigation of the possible mechanisms is left for future research.

[11] See Hoxby and Weingarth (2005) for an overview of the theoretical models.

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Table 1 Descriptive statistics

	Mean	Standard deviation
Graduated from high school	0.695	
Started an academic study track	0.458	
Started a vocational study track	0.511	
Higher education	0.362	
Proportion of girls	0.488	0.075
GPA	3.958	0.828
Girl	0.489	
First generation immigrant	0.036	
Second generation immigrant	0.020	
Both parents have compulsory education only	0.147	
At least one parent have a high school education	0.466	
At least one parent have a bachelor degree	0.285	
At least one parent have a master or doctoral degree	0.102	
Benefits due to disabilities or diseases	0.020	
Benefits due to private nursing or care	0.028	
Birth month	6.410	3.36
Parents married	0.606	
Parents divorced	0.126	
Parents never married	0.268	
Parental income in quartile 1	0.212	
Parental income in quartile 2	0.261	
Parental income in quartile 3	0.264	
Parental income in quartile 4	0.263	
Both parents employed	0.700	
Only mother employed	0.109	
Only father employed	0.135	
Cohort 2002	0.320	
Cohort 2003	0.328	
Cohort 2004	0.352	
Number of students at the compulsory school	88.651	44.81
Observations	160517	

Table 2 Simple OLS regressions

	Graduated high school	Academics study track	Vocational study track	Higher education
Proportion of girls	0.0490***	-0.0142	0.0262	0.0321*
	(0.0184)	(0.0220)	(0.0228)	(0.0171)
Girl	-0.0252***	-0.0348***	0.0192***	0.0584***
	(0.00217)	(0.00262)	(0.00277)	(0.00234)
GPA	0.286***	0.293***	-0.257***	0.271***
	(0.00141)	(0.00175)	(0.00200)	(0.00145)
First generation immigrants	0.0355***	0.194***	-0.207***	0.0925***
	(0.00637)	(0.00663)	(0.00715)	(0.00640)
Second generation immigrants	0.0384***	0.190***	-0.186***	0.0785***
	(0.00735)	(0.00928)	(0.00918)	(0.00817)
High school education	0.0496***	-0.00146	0.0168***	0.0102***
	(0.00353)	(0.00326)	(0.00358)	(0.00291)
Bachelor degree	0.0510***	0.0910***	-0.0848***	0.0775***
	(0.00385)	(0.00391)	(0.00415)	(0.00357)
Master or doctoral degree	0.0354***	0.149***	-0.155***	0.116***
	(0.00452)	(0.00502)	(0.00518)	(0.00503)
Benefits due to disabilities or diseases	-0.00257	0.0208**	-0.0241***	0.0198***
	(0.00784)	(0.00829)	(0.00885)	(0.00759)
Benefits due to needs for private nursing	-0.0694***	0.000763	-0.00339	0.00662
	(0.00726)	(0.00724)	(0.00794)	(0.00629)
Birth month	0.00339***	0.000572*	0.000448	0.00211***
	(0.000288)	(0.000310)	(0.000323)	(0.000296)
Married parents	0.0726***	-0.00202	0.00797***	0.0395***
	(0.00260)	(0.00268)	(0.00288)	(0.00251)
Divorced parents	0.0114***	-0.00826**	0.0129***	-0.000904
	(0.00344)	(0.00359)	(0.00387)	(0.00321)
Both parents employed	0.0779***	-0.0281***	0.0695***	0.0106**
	(0.00556)	(0.00562)	(0.00609)	(0.00498)
Only mother employed	0.0473***	-0.00462	0.0433***	0.00258
	(0.00554)	(0.00552)	(0.00607)	(0.00480)
Only father employed	0.0392***	-0.0190***	0.0478***	-0.00765
	(0.00554)	(0.00557)	(0.00615)	(0.00499)
Parental income in quartile 2	0.00525	-0.00391	0.00796**	-0.00697**
	(0.00361)	(0.00360)	(0.00386)	(0.00333)
Parental income in quartile 3	0.0219***	0.0287***	-0.0208***	0.0141***
	(0.00389)	(0.00400)	(0.00423)	(0.00375)
Parental income in quartile 4	0.0212***	0.0911***	-0.0857***	0.0420***
	(0.00401)	(0.00426)	(0.00443)	(0.00417)
Number of students at compulsory school	0.000271***	0.000737***	-0.000674***	0.000401***
	(3.64e-05)	(4.55e-05)	(4.57e-05)	(3.49e-05)
Cohort 2003	-0.0109***	-0.0255***	0.0281***	-0.0109***
	(0.00365)	(0.00460)	(0.00472)	(0.00359)
Cohort 2004	-0.0114***	-0.0365***	0.0363***	-0.00852**
	(0.00361)	(0.00469)	(0.00478)	(0.00357)
Constant	-0.652***	-0.784***	1.543***	-0.886***
	(0.0121)	(0.0140)	(0.0152)	(0.0108)
Observations	160,517	160,517	160,517	160,517
R-squared	0.315	0.316	0.257	0.300

Note: Standard errors are clustered at the cohort and compulsory school level are reported in parenthesis.

Table 3 Fixed effects regressions

	Graduated high school	Academic study track	Vocational study track	Higher education
Proportion of girls	0.0560***	-0.0100	0.0216	0.0479***
	(0.0148)	(0.0169)	(0.0176)	(0.0150)
GPA	0.292***	0.298***	-0.260***	0.278***
	(0.00138)	(0.00174)	(0.00199)	(0.00145)
Observations	159,802	159,802	159,802	159,802

Note: Standard errors clustered at the cohort and compulsory school level are reported in parenthesis. Compulsory school fixed effects included.

Table 4 Reduced samples without small schools

Sample	All schools	Only schools with at least 24 students	Only schools with at least 15 students
Panel A: Graduation from high school			
	(1)	(2)	(3)
Proportion of girls	0.0560***	0.0724***	0.0660***
	(0.0148)	(0.0194)	(0.0180)
GPA	0.292***	0.292***	0.292***
	(0.00138)	(0.00143)	(0.00140)
Observations	159,802	148,051	153,937
Panel B: Enrolled in higher education			
	(1)	(2)	(3)
Proportion of girls	0.0479***	0.0656***	0.0667***
	(0.0150)	(0.0203)	(0.0188)
GPA	0.278***	0.279***	0.279***
	(0.00145)	(0.00151)	(0.00148)
Observations	159,802	148,051	153,937

Note: Standard errors clustered at the cohort and compulsory school level are reported in parenthesis. The model specifications are similar to the model specifications in table 3, except as indicated.

Table 5 The proportion of girls instrumented with the proportion of girls at the municipality level

	Graduated reduced form	Higher education reduced form	First stage regression	Second stage Regression Graduated	Second stage Regression Higher education
Proportion of girls				0.0657**	0.0777***
				(0.0273)	(0.0266)
Proportion of girls at the municipality level	0.0647**	0.0731***	0.944***		
	(0.0256)	(0.0251)	(0.00147)		
GPA	0.292***	0.278***	0.0000055	0.292***	0.278***
	(0.00138)	(0.00145)	(0.000183)	(0.00139)	(0.00146)
Observations	159,883	159,883	159,799	159,799	159,799
R-squared	0.311	0.294	0.329	0.335	0.315
F value			4121.40		

Note: Standard errors clustered at the cohort and compulsory school level are reported in parenthesis. The model specifications are similar to the model specifications in table 3, except as indicated.

Table 6 Exam grades as instruments for GPA

	Graduated reduced form	Higher education reduced form	First stage regression	Second stage Regression Graduated	Second stage Regression Higher education
Proportion of girls	0.0393**	0.0297*	-0.0821***	0.0625***	0.0546***
	(0.0160)	(0.0167)	(0.0312)	(0.0151)	(0.0157)
GPA				0.282***	0.303***
				(0.00227)	(0.00231)
Exam	0.136***	0.146***	0.482***		
	(0.00127)	(0.00124)	(0.00215)		
Exam in Mathematics	0.0385***	0.0406***	0.125***	-0.00316	0.00266
	(0.00239)	(0.00206)	(0.00529)	(0.00224)	(0.00246)
Exam in Norwegian	0.00630**	0.0128***	0.0251***	-0.00079	0.00521*
	(0.00272)	(0.00299)	(0.00636)	(0.00268)	(0.002887)
Observations	153,664	153,664	153,664	153,664	153,664
F values			50497.62		

Note: Standard errors clustered at the cohort and compulsory school level are reported in parenthesis. The model specifications are similar to the model specifications in table 3, except as indicated.

Table 7 Excluding GPA, specific time trends and peer characteristics

	Excluding GPA		School specific time trends		With all peer characteristics	
	Graduated high school	Higher education	Graduated high school	Higher education	Graduated high school	Higher education
Proportion of girls	0.0355**	0.0360**	0.0522***	0.0263	0.0758***	0.0640***
	(0.0154)	(0.0157)	(0.0186)	(0.0192)	(0.0149)	(0.0151)
GPA			0.294***	0.279***	0.292***	0.278***
			(0.00140)	(0.00147)	(0.00138)	(0.00145)
Observations	162,669	162,669	159,802	159,802	159,802	159,802

Note: Standard errors clustered at the cohort and compulsory school level are reported in parenthesis. The model specifications in column (1)-(4) are similar to the model specifications in table 3. In column (5) and (6) I have calculated, and included, peer characteristics for all control variables in addition to the standard version of the control variables.

Table 8 Heterogeneity effects for different genders and parental education levels

	Boys	Girls	Low educated parents	High educated parents
Panel A: Graduated from high school				
Proportion of girls	0.0543***	0.0637***	0.0586***	0.0623***
	(0.0201)	(0.0201)	(0.0184)	(0.0218)
GPA	0.296***	0.289***	0.313***	0.250***
	(0.00180)	(0.00203)	(0.00161)	(0.00246)
Observations	81,638	78,164	97,948	61,854
Panel B: Enrolled in higher education				
Proportion of girls	0.0246	0.0427*	0.0179	0.0740***
	(0.0194)	(0.0229)	(0.0175)	(0.0275)
GPA	0.252***	0.299***	0.259***	0.304***
	(0.00200)	(0.00205)	(0.00178)	(0.00236)
Observations	81,638	78,164	97,948	61,854

Note: Standard errors clustered at the cohort and compulsory school level are reported in parenthesis. The model specifications are similar to the model specifications in table 3, except as indicated.

Table 9 Heterogeneity effects for different GPA levels

	GPA in quartile 1	GPA in quartile 2	GPA in quartile 3	GPA in quartile 4
Panel A: Graduated from high school				
Proportion of girls	0.0494	0.113***	0.0278	0.0124
	(0.0309)	(0.0358)	(0.0267)	(0.0180)
GPA	0.309***	0.405***	0.209***	0.0310***
	(0.00499)	(0.0131)	(0.00935)	(0.00482)
Observations	42,547	38,053	42,134	37,068
Panel B: Enrolled in higher education				
Proportion of girls	-0.00450	0.0338	0.0883**	0.0239
	(0.0114)	(0.0289)	(0.0344)	(0.0335)
GPA	0.0576***	0.341***	0.393***	0.185***
	(0.00205)	(0.0116)	(0.0137)	(0.00931)
Observations	42,547	38,053	42,134	37,068

Note: Standard errors clustered at the cohort and compulsory school level are reported in parenthesis. The model specifications are similar to the model specifications in table 3, except as indicated.

Figure 1 Proportion of girls in small schools

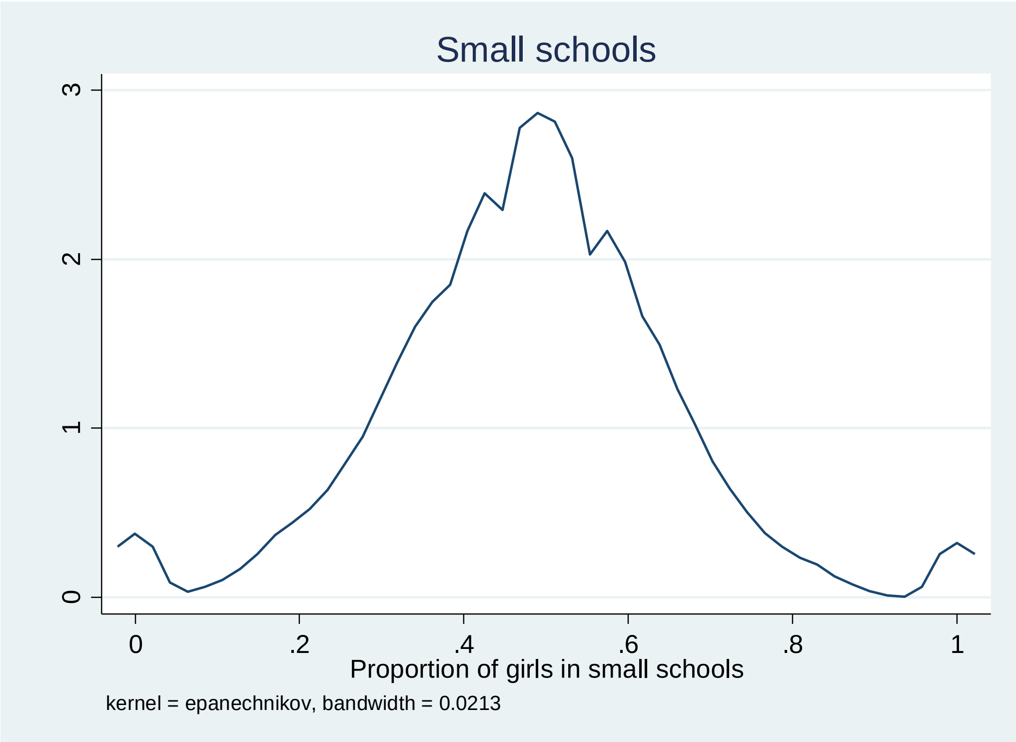
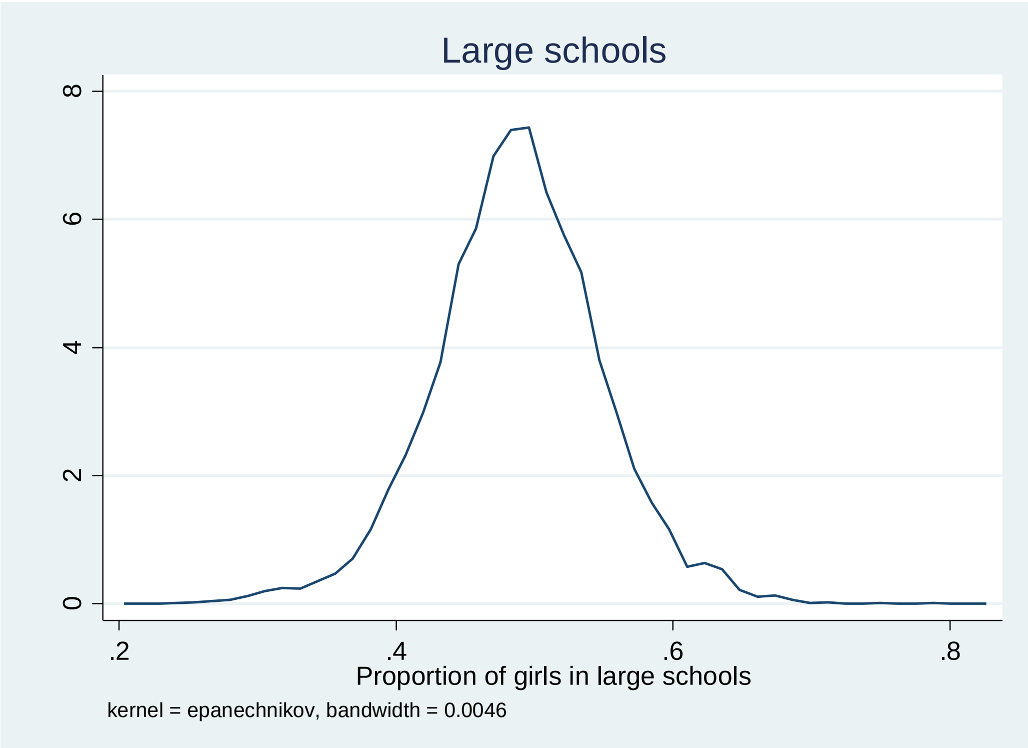


Figure 2 Proportion of girls in large schools



Appendix

Appendix table A1

	Observations	Percent of population
Total population. All students graduating from compulsory education in 2002-2004	174067	100
Not 16 when starting high school	10059	5.78
Missing grade information	3380	1.94
Missing peer information	87	0.05
Missing parents marital status	24	0.01
Regression sample	160517	92.22

Appendix table A2 Proportion of girls as the dependent variable

	(1)	(2)	(3)
GPA	-0.00132***	-0.00161***	
	(0.000186)	(0.000216)	
Girl	-0.00635***		
	(0.000365)		
First generation immigrants	-0.00108*	-0.00123*	-0.00128*
	(0.000647)	(0.000692)	(0.000692)
Second generation immigrants	0.000958	0.000584	0.000462
	(0.000777)	(0.000791)	(0.000791)
High school education	0.000254	0.000778*	0.000394
	(0.000266)	(0.000463)	(0.000462)
Bachelor degree	-0.000241	0.00120**	0.000221
	(0.000273)	(0.000493)	(0.000476)
Master or doctoral degree	0.000140	0.00201***	0.000696
	(0.000333)	(0.000565)	(0.000543)
Benefits due to disabilities or diseases	0.00137	0.00106	0.00109
	(0.000989)	(0.00115)	(0.00115)
Benefits due to needs for private nursing	0.000917	-0.000436	0.000181
	(0.000820)	(0.000953)	(0.000946)
Birth month	1.85e-05	-5.83e-06	1.36e-05
	(3.87e-05)	(3.85e-05)	(3.85e-05)
Married parents	-0.000325	0.000117	-0.000222
	(0.000277)	(0.000339)	(0.000334)
Divorced parents	0.000152	-8.27e-05	-3.13e-05
	(0.000358)	(0.000420)	(0.000421)
Both parents employed	-4.78e-06	-0.000107	-0.000401
	(0.000292)	(0.000731)	(0.000729)
Only mother employed	-0.000267	-0.000892	-0.00116*
	(0.000418)	(0.000698)	(0.000695)
Only farther employed	-0.000198	-0.000719	-0.000891
	(0.000381)	(0.000707)	(0.000706)
Parental income in quartile 2	-3.38e-06	-0.000357	-0.000384
	(0.000341)	(0.000510)	(0.000510)
Parental income in quartile 3	-0.000129	-0.000553	-0.000709
	(0.000293)	(0.000533)	(0.000531)
Parental income in quartile 4	-0.000179	-0.000640	-0.000980*
	(0.000297)	(0.000532)	(0.000527)
Cohort 2003	0.00474**	-3.70e-05	-3.69e-05
	(0.00215)	(9.35e-05)	(9.35e-05)
Cohort 2004	0.000420	0.00694***	0.00688***
	(0.00212)	(0.00256)	(0.00256)
Number of students in compulsory school	-3.02e-06	0.00430	0.00420
		(0.00834)	(0.00829)
Observations	159,802	159,802	159,802
F value		4.39	1.24

Note: Each row in column (1) represents a separate regression for the proportion of girls at school. All regressions include compulsory school fixed effects. Standard errors clustered at the cohort and compulsory school level are reported in parenthesis.