Girls, girls, girls: gender composition and female school choice

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Working Paper No. 0907
June 2009

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Abstract

Gender segregation in the labor market may be explained by women's reluctance to choose technical occupations, although the foundations for career choices are certainly laid earlier, during education. Educational experts claim that female students are doing better in math and science and are more likely to choose those subjects if they are in single-sex classes. Possible explanations are the lack of self-confidence of girls in male-dominated subjects, the dominating behavior of boys in the classroom and unequal treatment by teachers. In this paper, we identify the causal impact of gender composition in coeducational classes on the choice of school type for female students. We propose that girls are less likely to choose a female-dominated school type at the age of 14 after spending the previous years in classes with a higher share of female students. We address the problem of endogenous school choice by using natural variation in gender composition of adjacent cohorts within schools. The results are clear-cut and survive powerful falsification and sensitivity checks: Females are less likely to choose a female-dominated school type and more likely to choose the technical school type if they were exposed to a higher share of girls in previous grades. Our paper contributes to the recent debate about coeducation either in certain subjects or at the school level.

JEL Classification: I21, I28, J24
Keywords: gender segregation, coeducation, career choice

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We would like to thank Rudolf Winter-Ebmer, Martin Halla, Mario Schnalzenberger and Victor Lavy as well as participants of the ESPE conference 2008 in London, the EEEPE conference 2008 in Amsterdam, the Annual Meeting of the Austrian Economic Association 2009 in Linz and seminar participants in Neufelden 2008 and at BeNA in Berlin 2009 for helpful comments. We thank the Austrian Science Fund FWF (NRN Labor & Welfare State) for funding as well as the the municipality of Linz for providing us the data and a research grant.

1 Introduction

While gender gaps in employment rates tend to narrow in most OECD countries, the earnings differentials between men and women are still pronounced (see e.g. Weichselbaumer and Winter-Ebmer, 2005). One explanation for the persistency in the gender wage gap is the high degree of occupational segregation. Men and women are still concentrated in different occupations and men have "chosen" the prestigious, powerful and well-paid jobs. The situation has not changed substantially since the 1970s, women predominantly work as clerks, in sales jobs, as teachers and in life-science and health professions, while men are found in physical, mathematical and engineering jobs, in managerial occupations and in manual and production jobs (Coré, 1999; OECD, 2002).

The high degree of gender segregation in the labor market may be explained by women's reluctance to choose technical and male-dominated occupations, although the foundations for their career choices are certainly laid much earlier, i.e. during education. While educational attainment has converged across gender, considerable differences can be found in the fields of studies. Machin and Puhani (2003) show that in the UK and Germany, in 1996, male and female students were strongly segregated among different degree subjects. This segregation translates into occupational segregation on the labour market and explains between 8 and 20% of the overall gender wage gap. Ten years later, the situation is not much different. In the OECD, the share of female graduates in science and engineering was about 30% between 2004 and 2006. On the other hand, more than 75% of graduates in education, health and social services were females (OECD, 2004-2006).

What is the driving force behind the high degree of gender segregation in fields of studies and how can education policy make a difference? The debate on coeducation and single-sex schooling is closely related to this issue. Educational experts claim that girls are doing better in male-dominated subjects, like math and science and are more likely to choose those subjects if they are in single-sex classes. Proponents of single-sex education argue that it gives more freedom in exploring interests and abilities, while coeducational settings reinforce gender-stereotypes. Possible explanations for the reinforcement of gender-stereotypes in coeducational schools are the lack of role-models and self-confidence of girls in subjects like math and science, the dominating behavior of boys in the classroom and an unequal treatment of boys and girls by teachers.

We do not investigate single-sex schools or classes but focus on the impact of gender composition within coeducational schools. We propose that girls are less likely to choose a female-dominated school type and are more likely to choose a technically-oriented or male-dominated school type at the age of 14 after spending the previous years in classes with a higher share of female students.

We test this generic hypothesis in the context of secondary school choice in the Austrian education system. Like many other countries, Austria has an education system that is characterized by a strong vocational orientation.[1] A multitude of intermediate and higher vocational school types are available, providing specific education, such as technical, business or domestic education. Some of those school types are indeed dominated by one gender. In Linz, the third largest city in Austria, the mean share of females in technical schools between 1979 and 2002 was 5% on average and below 9% in each single year. In schools for domestic sciences, on the other hand, about 94% of students were females (Statistik Austria, 1979-2002).

We identify the causal impact of gender composition on the choice of school type for female students. Since the share of girls in schools is endogenous, we use population variation in the gender composition of adjacent cohorts within schools. School-specific time trends control for school trends in unobserved factors that may be correlated with the share of girls in a certain grade. The analysis is based on register data, covering 19 cohorts of compulsory school students from Linz.

The paper proceeds as follows. Section 2 gives an overview of the related literature from economic research as well as other disciplines and outlines our contribution. The literature review gives insight into the mechanisms and consequences of gender role formation and possible answers to the question, why gender composition in class should influence academic outcomes. Section 3 describes the research design, section 4 presents the results and section 5 contains powerful falsification and sensitivity checks. Finally, section 6 concludes.

2 Previous studies and our contribution

It is a well known fact that men and women choose different majors and graduate in different fields of studies. Many factors influence the choice of major, such as prior achievement in various subjects, (closely related) the individuals' preferences for various subjects, the school or college environment or labor market expectations. Turner and Bowen (1999) focused on the explanatory power of prior test scores for men's and women's choices of studies in the US. The authors conclude that a small part of the gender gap in fields of studies can be explained with differences in verbal

[1] In Germany, Switzerland, Italy, Belgium, Finland, the Netherlands, the Czech Republic, the Slovak Republic, Australia and Austria more than 60% of upper secondary education students attended a pre-vocational or vocational school between 2004 and 2006 (OECD, 2004-2006).

and math SAT scores. In engineering, about 31% of the gender gap can be explained with prior achievement, while in economics the fraction is even lower, about 17%.

Next to skills, organizational characteristics of schools and colleges seem to be influential. Previous research has shown that successful women in male-dominated fields disproportionately graduated from single-sex colleges (Tidball, 1985, 1986). It seems that female colleges benefit women with respect to their occupational choices. However, students in coeducational and single-sex colleges might be different in terms of ability and aspirations and many unobserved factors may contribute to these results. In this context, Solnick (1995) used a more sophisticated empirical framework. She compared about 1,400 females in single-sex colleges with about 700 female students in comparable coeducational colleges in the US. Data on intended majors at the beginning of college as well as final majors at the end are available. She found that women in the single-sex schools are more likely to switch to a different major during their studies. The presence of female students or other unobserved characteristics of single-sex colleges encourage the students to shift from intended female-dominated to neutral or male-dominated majors. A comparable study was undertaken by Billger (2002), who investigated alumni from a female college that became coeducational. After the admission of men, female students were less likely found in male-dominated subjects and occupations.

Coeducation versus single-sex schooling is an ongoing debate in primary and secondary education, too. The proponents of single-sex schooling argue that coeducational settings reinforce gender-stereotypes, while single-sex schooling gives more freedom in exploring interests and abilities, especially for female students. Two studies of Billger (2007, 2009) support this idea: female students from high-schools with more than 75% females earn higher wages later on, and the college majors of students from single-sex secondary private schools are less segregated by gender than those of coeducated students. However, selection issues might be a problem.

Studies in educational science show that female students are doing better in male-dominated subjects, like math and science and are more likely to choose those subjects if they are in single-sex classes. For boys, this phenomenon seems to be less pronounced. While some authors conclude that boys in single-sex environments are doing better on reading and writing tests and are more likely to choose subjects like biology or languages, other studies find no significant differences (see for example Haag, 1998; Stables, 1990).

There are several reasonable explanations for these findings. First, the gender composition might have an influence on ones self-concept and self-esteem in subjects, that are perceived as inappropriate for the own sex. In this regard, developmental psychologists talk about "gender intensification" and mean a period in adolescence in which children are extra-sensitive to gender-roles. With the beginning of puberty, boys and girls strongly adhere to gender-stereotypes and each departure from traditional gender roles is appraised as inappropriate (Galambos, 2004; Lobel et al., 2004).[2] When boys and girls are educated together, their strong beliefs about the gender-appropriateness of attitudes and activities are amplified and they tend to conform to gender roles more strongly. Social cognition research shows that gender identity and the related self-concept of abilities (how people rate themselves in terms of various abilities) is influenced by the social environment. Since gender is more salient in a coeducational setting, the self-concept of own abilities in various subjects is strongly determined by the knowledge about masculinity and femininity a person has. In single-sex schools, on the contrary, gender is not a useful category to think about and gender-related knowledge and beliefs are less important in constructing a self-concept of own abilities and interests.

In a randomized experiment, Kessels and Hannover (2008) show that girls reported a significantly higher self-concept of physics-ability after being taught in single-sex classes. About 400 students in Berlin were randomly assigned to mixed and single-sex classes in physics throughout the 8^{th} grade. After one year the students' self-concept of physics ability and their gender-related self-knowledge (how they identify themselves with feminine and masculine traits) were measured. Girls who were taught in single-sex classes reported a higher self-concept in physics ability than girls in mixed classes. For the boys' self-concept in physics the gender composition did not play a role. Furthermore, boys and girls in single-sex classes identified themselves with feminine and masculine adjectives more flexibly. In other studies, similar results were obtained (Brutsaert, 1999; Haag, 1998).

Besides gender identity formation, the atmosphere and learning climate as well as pupil-teacher relations may be different in single-sex classrooms. There is substantial social science research on gender differences in classroom interactions, showing that males are given and attracting a higher amount of teacher attention (Beaman et al., 2006; Einarsson and Granström, 2002; Sadker et al., 1991). Teacher beliefs about gender differences in various subjects might also play a role. In a review about gender related teacher beliefs in mathematics, Li (1999) concludes that teachers tend to stereotype mathematics as a male domain, which is reflected in their propensity to underrate the abilities of girls and overrate that of boys. On the contrary, a discrimination bias against male students was found by Lavy (2008). A natural

[2] In an experimental setting, Lobel et al. (2004) have shown that in young adulthood gender-flexibility and counter-stereotypical behavior gets much more accepted than during adolescence.

experiment based on blind and non-blind test scores in Israeli public high-schools shows that teachers' grading practices harm boys in all investigated humanity and science subjects.

The gender composition of the environment plays a role for other outcomes as well. Booth and Nolen (2009*a*,*b*) conducted economic experiments on gender differences in risk taking and competitive behavior. The results support the idea that girls strongly respond to the gender composition. Female adolescents from single-sex schools (long-term effects) as well as those who were randomly assigned to all-girls experimental groups (short-term effects) behave like boys in terms of risk and competition behavior. Compared to their female peers in mixed-gender environments, they reveal less risk-averse preferences and shy away from competition less likely.

In this paper, we are looking at the choice of school type of 14-year-old compulsory school students in Austria. Our study contributes to the literature in multiple ways. First, we do not compare students from single-sex schools to coeducated students, but focus on the share of females within schools. Single-sex schools might differ from coeducational schools in many other ways than gender composition, such as teaching principles or school philosophies. We are looking at coeducational schools and therefore analyzing a general situation, most students in almost all education systems are exposed to. Second, we are interested in the choice of (vocational) school type. In all education systems, either at some stage in upper secondary education or later on, students have to choose between different occupational orientations, be it a specific type of school or college major. Thus, the topic is not only relevant for Austria, or for schooling systems with a high degree of vocational orientation, but it is a general mechanism that we are interested in. Third, we are able to estimate the causal impact of the proportion of girls in the grade on the choice of school type for female students by using natural variation in gender composition of 19 adjacent cohorts. Our paper is the first one, studying this topic with a credible identification strategy.

The studies of Hoxby (2000), Lavy and Schlosser (2007) and Proud (2008) are related to our paper, since they also used population variation to identify the causal effect of gender composition on educational outcomes. However, these studies focused on student achievement in general and the identification of peer group effects in particular. Gender identity formation, which is the main argument in our paper, does not play a role. Hoxby (2000) and Lavy and Schlosser (2007) found a positive impact of the fraction of females in the classroom on cognitive outcomes in math and reading. Proud (2008) obtained similar results for math and science, but found a negative effect of a more female classroom on boys' English test scores and no effect for girls in English. The results for English support our hypothesis, i.e. the share of the own sex increases the self-concept of ability in subjects perceived as not appropriate for the own sex.

3 Research design

This section presents the research design. First, we explain our econometric model and the identification strategy (section 3.1). Then, based on the institutional conditions of the Austrian education system and the available register data (section 3.2), we develop our estimation samples and present some descriptive statistics (section 3.3). In section 3.4, we define male and female-dominated school types and describe some details of our estimation methods.

3.1 Identification strategy

Our hypothesis is that girls are less likely to choose a female-dominated school type and more likely to choose a male-dominated school type at the age of 14 after spending the previous years in grades with a higher fraction of female students. The gender mix in schools may be endogenous and correlated with unobserved student or school characteristics, such as educational orientations in terms of subjects or teaching methods. Our identification strategy relies on random variation in gender composition of adjacent cohorts within schools, resulting solely from natural variation in the gender composition of birth cohorts.

Our econometric model can be written as:

$$Female^*_{ist} = \beta_0 X'_{ist} + \beta_1 G_{st-x} + \beta_2 Girls_{st-x} + \gamma_s + \delta_{1s} t_{st-x} + \delta_{2s} t^2_{st-x} + \delta_{3s} t^3_{st-x} + \epsilon_{ist}$$

$$Female_{ist} = \begin{cases} 1 & \text{if } Female^*_{ist} > 0 \\ 0 & \text{otherwise.} \end{cases}$$

where $Female^*_{ist}$ is the latent probability of student i in year (cohort) t coming from school s to choose a female-dominated school type in grade 9. X'_{ist} and G_{st-x} capture individual characteristics of the students and the size of the grade. $Girls_{st-x}$ gives the fraction of girls in school s at time $t-x$, where $x = \{4, 3, 2, 1\}$ capturing grade 5-8. γ_s is a school fixed effect and $\delta_{1s} t$, $\delta_{2s} t^2$ and $\delta_{3s} t^3$ are school-specific cubic time trends. The error term ϵ_{ist} consists of an individual-specific and a school-specific random part. We are interested in the coefficient β_2, which should have a negative sign.

Note that the time trends are school-specific and control for school trends in unobserved factors that may be correlated with the share of females in a certain grade. If a certain school starts a campaign to promote girls in technical subjects, the share of females might increase as well as the probability of those females to choose male-dominated school types in grade 9. Relying on school fixed effects only would bias β_2 upwards. On the other hand, if a school introduces enrichment activities in foreign languages, the share of female students might increase as well as the probability of those females to choose female-dominated school types. In this case β_2 would be biased downwards. Controlling for very flexible time trends in each single school separately should eliminate this problem.

We focus on the grade level in schools and not on classes. As will be described below, we estimate our model for students in low track schools. In Austria, those students are streamed in the main subjects German, Mathematics and English. In each subject three classes are formed on the basis of student achievements. The students spend most of their time in school with their classmates but are taught together with other students from the grade in the main subjects. Furthermore, although ability grouping across classes is not common in Austria, a certain degree of selectivity at the class level can not be ruled out entirely.[3]

3.2 Data and institutional framework

We use register data covering compulsory school students in Linz, an Austrian city of about 189,000 inhabitants. We observe some basic individual characteristics of the students (age, sex, native language) and the nine compulsory years of their school career (school types, schools and classes), usually grades 1 to 9. The variable of interest is school type in grade 9, which is observed for 19 cohorts between 1988 and 2006.

The structure of the Austrian education system is presented in figure 1. After four years of comprehensive primary schooling, students have to choose between two school types, the lower secondary school (*low track*) and the first stage of the higher general school (*high track*). The track choice is made by students and their parents, depending on previous academic records and recommendations of primary school teachers. Low track schools differ from high track schools in many aspects. High track schools offer an academically preferable curriculum, teachers have higher educational qualifications and earn higher salaries. However, there are no 'formal' differences in educational opportunities later on.

[3] The proportions of female students at the grade-level and at the class-level are highly correlated, with a correlation coefficient of about 0.75.

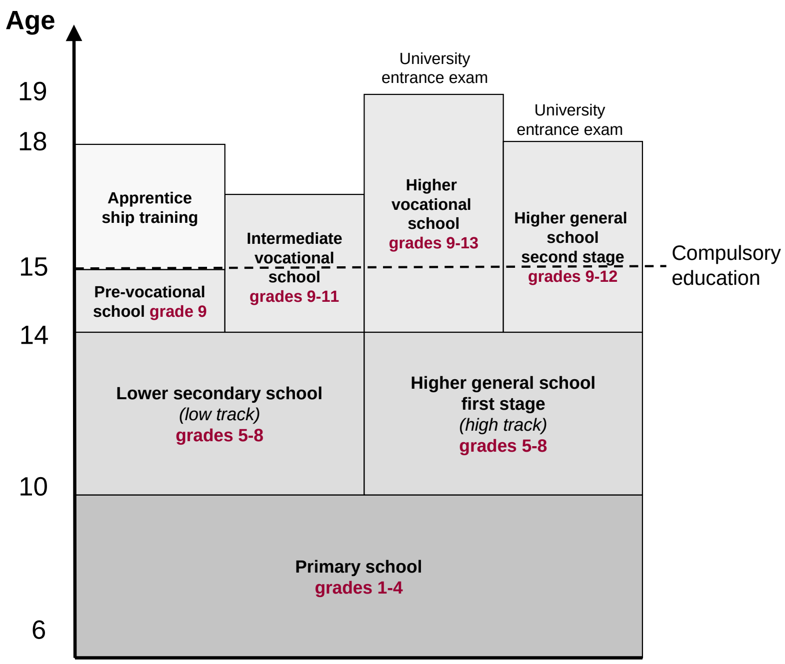

Figure 1: Austrian education system

Figure 2 shows the distribution of students among high and low track schools in Linz, compared to the whole country and the capital Vienna. 70% of all Austrian students went to low-track schools in the school year 2005/06. While this share was significantly smaller in Vienna, the figure for Linz can be found in-between.

After grade 8, students again have to choose a school type. The pre-vocational school is a one-year school that should prepare students for various types of apprenticeship trainings. There is no occupational differentiation. Vocational schools consist of intermediate (grades 9-11) and higher (grades 9-13) school types, offering a range of vocational orientations (technical, business, domestic science and tourism, kindergarten teacher training[4]). In most cases the intermediate and higher vocational tracks of the respective orientations are located in the same buildings and students are taught by the same teachers. After the intermediate vocational school students enter the labor market directly, whereas after the higher vocational school students can choose between entering the labor market and starting tertiary education. The higher general school type lasts for four years and most students enter a post-secondary or tertiary education afterwards.

Figure 3 shows the distribution of students among school types in grade 9 for students coming from low and high track schools separately, again for Austria, Vienna

[4]The kindergarten teacher training schools are higher vocational schools. For this orientation, there are no intermediate forms.

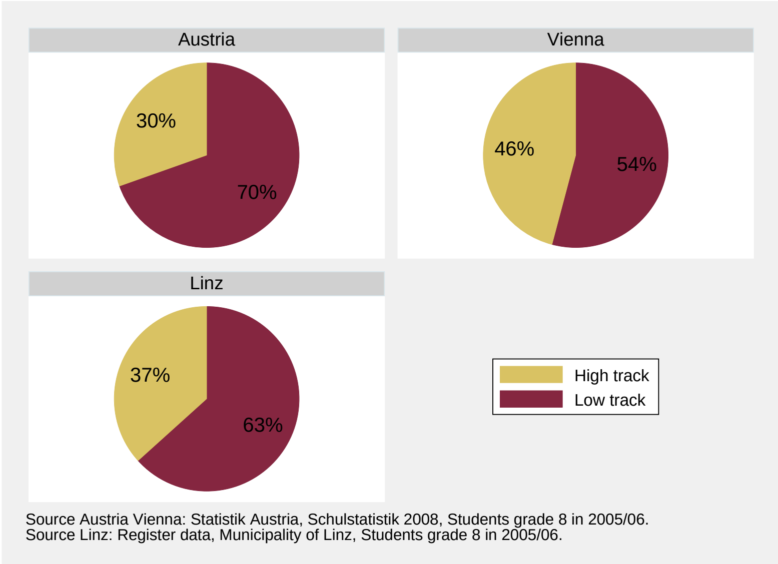

Figure 2: School types grade 8

and Linz. The higher and intermediate vocational schools are combined and plotted by orientations.

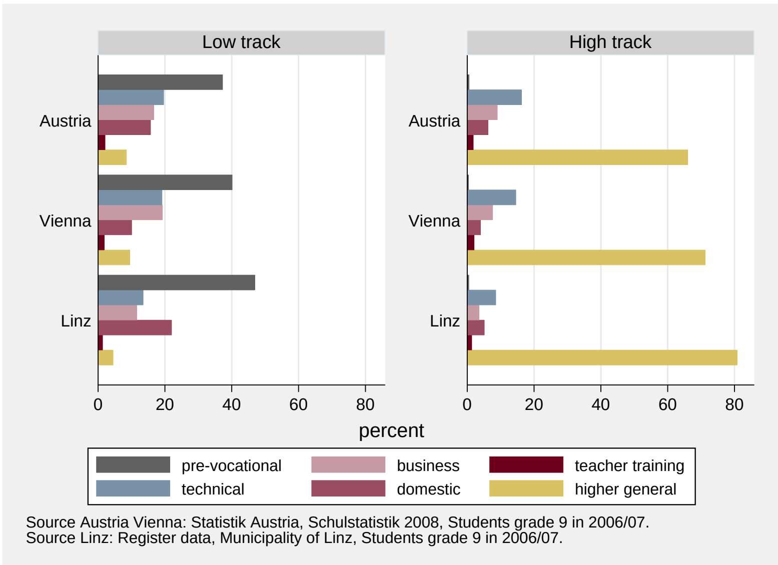

Figure 3: School types grade 9

Although there are no formal restrictions in school choice for low track students, the distribution of students coming from low and high track schools is very different. While students from low track schools choose the pre-vocational school very often, this school type is hardly ever chosen from high track students. The vast majority of high track students choose the higher general school, which is the second stage of the high track schools.[5]

3.3 Samples

We restrict our analysis to students in low track schools because of three reasons. First, while low track students have to make a real choice after grade 8, the vast majority of high track students choose, or better 'stay in', the higher general school. Thus, there is only little variation in school types for high track students. Second, in low track schools all students are observed in grades 5 to 8, while in high track schools not all students are observed. The reason is that students from neighboring municipalities can choose a high track school in Linz and these students are not included in our data. Hence, we are able to measure the fraction of girls in low track schools correctly, but not in high track schools. The third reason is school choice. Students opting for high track schools can choose any school, while low track school students usually go to the low track school in their catchment area, which is based on residency.[6]

Since we look at low track school students only, our sample is not representative for the whole population. However, on average 57.6% of all students, 56.2% of all female students and 58.8% of all male students have chosen a low track school after primary education in Linz between 1984 and 2002 (grade 5). While the total proportion of students in low track schools was very stable over time, the gender composition altered somewhat.[7] The proportion of students in low track schools is higher and amounts to about 62% if grade 8 is considered. Some students change school types between grade 5 and grade 8. Most of them start in the high track school and change to the low track school.

School choice in grade 9 is not observed for all students in our data. We predominantly do not observe students who repeated a grade or attended pre-school. However, whether we observe a student in grade 9 is not related to the fraction of girls in grade 5.[8] To sum up, our sample is selected in two ways. On the one

[5]In most cases, the high track schools and the higher general schools are located in the same buildings and students are taught by the same teachers.

[6]There are exceptions. Parents can file an application and opt for a different low-track school outside the catchment area if there are good reasons, e.g. parents work in a different neighborhood or siblings go to a school in a different neighborhood.

[7]In the first half of our sample period, 1984-1993, 56.8% of females and 58.1% of males attended a low track school. These numbers changed to about 55.6% for females and 59.6% for males in the second half, 1994-2002. Thus, low track schools are generally dominated by male students and this domination got more pronounced over time. To account for this problem, we split the sample and estimated our models for the two subperiods separately. The results are virtually the same.

[8]See section A for more information on this issue.

hand, our sample is negatively selected because we concentrate on low track school students only. On the other hand, we do not have information for, predominantly, pre-schoolers, grade-repeaters and drop-outs, implying a positive selection of students from low track schools.

Table 1: Summary statistics of student and grade-level variables

	Grade 5		Big Sample	
Variables	Mean	Stdev	Mean	Stdev
Student-level variables				
Female	0.450		0.450	
Age in grade 9	14.691	0.424	14.706	0.438
Foreign language	0.111		0.125	
Grade-level variables				
Grade size	57.784	17.172	57.996	17.093
Fraction of girls	0.436	0.114	0.436	0.112
Preschool and grade repetition				
Preschool	0.134		0.135	
Grade repetition	0.049		0.044	
Number of observations	6,769		7,472	
Number of low track schools	18		18	

Notes: For 0.27% of students in the grade 5 sample and 0.43% of students in the big sample the information on native language is missing, these observations are not dropped, but a missing dummy is included in the estimations. The big sample consists of students in grade 5 (90%), grade 6 (4%), grade 7 (3%) and grade 8 (3%).

Table 1 shows summary statistics for two estimation samples, one for grade 5 and one that is called big sample. Grade 5 is the first year in a certain school. Therefore, students and their parents with certain unobserved preferences for female or male classes are not able to anticipate the gender composition when they decide to enroll in a school. Selection bias on the basis of the fraction of girls can therefore be ruled out for grade 5. From grade 6 to grade 8 some students have changed schools and in some cases these decisions might be correlated with the gender composition they were exposed to. Thus, gender composition in grades 6 to 8 might be endogenous, even if population variation is used to estimate the model. For these reasons we focus on grade 5. Additionally, we constructed a big sample where we use grade 5 information primarily but for those students with missing values (e.g. because they moved to Linz), we use grade 6, grade 7 or grade 8.

Since the share of girls in grade 8 might be more important for school choice in grade 9 than the share of girls in grade 5, we regard our estimates as lower bounds and show further regressions as well as IV estimates in section 5.3.

In the sample period, there were 20 low track schools in Linz; three of them were private schools, among them two girls' schools. These two single-sex female schools were dropped from the sample. Table 2 shows the variation in gender composition, decomposed into between and within school components for all 20 schools, the 18 coeducational schools as well as the 17 public coeducational schools.

Table 2: Variance of the fraction of girls in grade 5 between and within schools

Variation of *Girls*	Sum of squares	Share of total	N
All low-track schools			
Between	0.03542	83.60%	20
Within	0.00695	16.40%	18.50
Mean of *Girls*	0.500		
Coeducational schools			
Between	0.00693	47.24%	18
Within	0.00774	52.76%	18.44
Mean of *Girls*	0.443		
Coeducational public schools			
Between	0.00737	49.30%	17
Within	0.00758	50.70%	18.41
Mean of *Girls*	0.444		

NOTES: Three of all low-track schools are private schools and two of them are female single-sex schools.

The variation in the fraction of girls within schools is about 53% in coeducational low track schools and 51% when the private school is dropped. Our preferred estimations are based on the 18 coeducational low track schools.[9] The variation within schools over time/cohorts seems to be sufficient for the estimation of our econometric model. Since the larger part of variation is found within schools, and not between, a high degree of selectivity on the basis of gender composition seems unlikely.[10]

3.4 Female and male-dominated school types

In Austria, 14-year-old students can choose between a variety of different school types, some of which are traditionally female dominated and others are traditionally male dominated. The classification of schools into female and male dominated ones is based on the following criteria: (i) typical occupations the school types are preparing for, (ii) the fraction of female students in these schools and (iii) instructional time in math and science. Table 3 shows the different school types and the applied classifications.

[9]The results are almost identical, when only the 17 public coeducational schools are used to estimate the models.

[10]The within school variation does not only stem from small schools. From all 18 coeducational schools, the within school component is 40.47% for the 9 biggest schools and 68.17% for the 9 smallest schools.

Table 3: Traditionally female and male dominated school types

School type	teacher training	domestic sciences	business schools	higher-general	pre-vocational	technical schools
Typical occupations	kinder-garten teachers, social occupations	in hotels and restau-rants, clerks	clerks, book-keepers	professionals (university)	crafts and services	engineers
Fraction females						
1979-1987	0.995	0.979	0.673	0.541	0.439	0.039
1979-2002	0.983	0.943	0.655	0.544	0.418	0.051
Classes per week						
Math	3	2.18	2.04	3.40	3.46	3.86
Science	2	2	2	2	1.61	4.54
% of all classes						
math & science	12.82	10.61	10.84	17.11	16.11	21.58
Binary Models						
Female weak	1	1	1	1	0	0
Female	1	1	1	0	0	0
Ordered Models						
Ordered	3 female	3 female	3 female	2 neutral	2 neutral	1 male
Ordered detail	5 female	5 female	4 female wk	3 neutral	2 male wk	1 male

NOTES: The figures of female shares are based on data from the central bureau of statistics (Schulstatistik Linz, Statistik Austria, 1979-2002). Classes per week in math and science are taken from the student questionnaires of PISA 2000 and 2003. The answers of all grade 9 PISA students are aggregated to the school level. The reported value refers to the median school from each school type. One class period consists of 50 minutes. Additionally, math and science classes are summed and given as percent of total classes per week for each school type.

We estimate binary as well as ordered models. In the binary case, we apply a weak definition for female domination in schools, simply determined by the share of females between 1979 and 1987 (the time span prior to our sample period). Female dominated school types are those with more than 50% female students *(Female weak)*. For a narrower definition, we employ a minimum female share of about $\frac{2}{3}$ and put weight on the typical occupations for which the students are prepared in those schools. As the table shows, the curricula of teacher-training schools, schools for domestic science and tourism as well as business schools are characterized by a relatively low degree of math and science education. Instructional time in math and science is below 13% in each school type *(Female)*.

To draw a more precise picture of gender aspects in the various school types, we estimate ordered models, with school types ordered by their degree of female domination. We estimate a three-category model with female, neutral and male school types *(Ordered)* and a five-category model with female, female weak, neutral, male weak and male school types *(Ordered detail)*. Table 4 shows the distribution of students in our sample among those school types.

Table 4: Distribution of students among school types

	Grade 5 Sample		
	All	Females	Males
Binary			
Female weak	0.333	0.526	0.175
Female	0.256	0.436	0.109
Ordered			
3 female	0.256	0.436	0.109
2 neutral	0.603	0.547	0.648
1 male	0.141	0.017	0.243
Ordered detail			
5 female	0.153	0.299	0.033
4 female weak	0.103	0.138	0.076
3 neutral	0.077	0.089	0.066
2 male weak	0.526	0.457	0.582
1 male	0.141	0.017	0.243
Number of observations	6,769	3,046	3,723

NOTES: Summary statistics of the binary and ordered dependent variables for the grade 5 sample. The figures for the big sample are virtually identical.

In a first step, we estimate linear probability models as well as logit models for choosing a weakly female dominated *(Female weak)* and a female dominated *(Female)* school type. In a second step, we estimate ordered logit models, using the three-category dependent variable *(Ordered)* as well as the five-category dependent variable *(Ordered detail)*.[11]

In both sets of models we control for the students' age at school choice, whether their first language is German and the size of the grade. We cluster standard errors at the school*year level because the observations are not independent within school cohorts.

As we are looking at female students only, the number of observations in our sample is higher for schools and grades with a higher share of female students. Thus, the treatment variable is positively correlated with the number of observations contributing to the estimation. To avoid any biases resulting from this fact, we additionally carry out weighted regressions with Weight $= \frac{1}{Girls}$.

[11] The results, reported in the next section, are not sensitive to this choice. When probit models are used instead of logit, the estimated marginal effects are almost identical.

4 Results

First, we present results for the binary models. Table 5 shows the estimated coefficients of the linear probability models as well as the marginal effects of the logit models for unweighted and weighted regressions. Each number represents a single regression including school-fixed effects, school-specific cubic time trends and some control variables.[12] The results are reported for the grade 5 and the big sample.

Table 5: Effects of *Girls* - Binary models

	Unweighted		Weighted		
	LPM (Coef)	Logit (ME)	LPM (Coef)	Logit (ME)	N
Female weak					
Grade 5	-0.357	-0.426	-0.429	-0.515	3046
	(0.162)**	(0.187)**	(0.166)**	(0.194)***	
Big Sample	-0.375	-0.430	-0.432	-0.504	3366
	(0.149)**	(0.171)**	(0.151)***	(0.177)***	
Female					
Grade 5	-0.425	-0.391	-0.481	-0.457	3046
	(0.140)***	(0.132)***	(0.143)***	(0.140)***	
Big Sample	-0.440	-0.378	-0.496	-0.430	3366
	(0.135)***	(0.117)***	(0.136)***	(0.121)***	

NOTES: Each coefficient and marginal effect represents a separate regression. School-fixed effects, school-specific cubic time trends, age, foreign, grade size, missing dummy for foreign included in all regressions. Big sample includes g6-g8 dummies. Heteroscedasticity and cluster-robust standard errors in parentheses (clusters are school-years). Weighted regressions: Weight = 1/Girls. ***, ** and * indicate statistical significance at the 1-percent, 5-percent and 10-percent level.

The estimated effects are similar across regressions and show the expected negative signs. The higher the share of girls in low track schools, the less likely a (weakly) female-dominated school type is chosen by female students in grade 9. The coefficients are somewhat larger in the weighted regressions. The estimates range from -0.36 to -0.52, with a mean of -0.43 for *female weak* and -0.44 for *female*. Increasing the share of girls by one standard deviation (0.11), decreases the probability of choosing a female-dominated school type by 4.8%-points, which is a reduction of 11%.

The results of the ordered models are given in table 6. The coefficients as well as the marginal effects for all possible outcomes are reported for the unweighted and weighted regressions of both samples. All coefficients of the three-category model are statistically significant and show a negative sign. The results give the same

[12] The results of both, the binary and ordered models, are not sensitive to the functional form of the school-specific time trends. The inclusion of polynomial time trends of the 4^{th} order does not change the results. If school-specific quadratic time trends are used instead of cubic ones, the estimates are very similar, with slightly higher standard errors.

Table 6: Effects of *Girls* - Ordered models

	Grade 5 Sample		Big Sample	
	unweighted	weighted	unweighted	weighted
Ordered				
Coefficient	-1.791	-2.092	-1.829	-2.118
	(0.614)***	(0.630)***	(0.588)***	(0.598)***
Marginal effects				
3 female	-0.439	-0.514	-0.449	-0.521
	(0.150)***	(0.155)***	(0.144)***	(0.147)***
2 neutral	0.416	0.490	0.427	0.498
	(0.142)***	(0.148)***	(0.137)***	(0.141)***
1 male	0.023	0.025	0.022	0.023
	(0.009)***	(0.008)***	(0.008)***	(0.007)***
Ordered detail				
Coefficient	-1.355	-1.603	-1.478	-1.695
	(0.595)**	(0.595)***	(0.569)***	(0.566)***
Marginal effects				
5 female	-0.274	-0.325	-0.301	-0.347
	(0.120)**	(0.120)***	(0.115)***	(0.116)***
4 female weak	-0.059	-0.069	-0.062	-0.071
	(0.027)**	(0.027)**	(0.025)**	(0.025)***
3 neutral	-0.005	-0.004	-0.005	-0.004
	(0.004)	(0.004)	(0.004)	(0.004)
2 male weak	0.319	0.379	0.350	0.403
	(0.140)**	(0.141)***	(0.135)***	(0.135)***
1 male	0.018	0.020	0.018	0.019
	(0.008)**	(0.008)**	(0.007)**	(0.007)***
Number of observations	3,046		3,366	

NOTES: School-fixed effects, school-specific cubic time trends, age, foreign, grade size, missing dummy for foreign included in all regressions. Big sample includes g6-g8 dummies. Heteroscedasticity and cluster-robust standard errors in parentheses (clusters are school-years). Weighted regressions: Weight = 1/Girls. ***, ** and * indicate statistical significance at the 1-percent, 5-percent and 10-percent level.

picture as those of the binary models. While the marginal effects for female school types are all around -0.48, the marginal effects for the technical school type are about +0.02. Thus, female students change from female-dominated school types to primarily neutral ones after spending the previous years of education with more girls in class. There is also a small effect for male-dominated school types.

The results of the five-category model are very similar. Here, female school types are solely teacher training schools and schools for domestic sciences, with female shares of above 90%. The probability of girls to choose these school types is decreasing in the proportion of female students, with a mean marginal effect of -0.31. For the weakly female dominated business schools, we get a small negative marginal effect. The neutral school types (from the 3-category model) are now divided into the neutral higher general schools and the weakly male dominated pre-vocational schools. Here, positive marginal effects are only found for the weakly male dominated school types. The technical male school type, with female shares of below 10%, is increasingly chosen if the share of females is higher.

All estimations show that the share of girls has an influence on school choice for female students. Whether this is due to female and male-domination and not due to other unobserved factors that are correlated with certain school types will be discussed in the next section.

5 Sensitivity checks

First, using placebo treatments, we show that the share of female students is really exogenous in our empirical framework and selection into low track schools does not play any role for the estimated coefficients. Furthermore, we concentrate on the question, why female students exposed to a higher share of girls choose different school types than other students do and wether this result is driven by unobserved achievement effects. Finally, we present further regressions for the grades 6-8 and IV estimates to show that our results should be regarded as lower bound estimates.

5.1 Placebo treatments

Is the share of female students in lower secondary schools really exogenous in our econometric model? Following Lavy and Schlosser (2007), we apply placebo treatments in which the actual share of girls the students were exposed to ($Girls_{st-x}$) is replaced with the share of girls in the previous ($Girls_{st-x-1}$) and the following year $Girls_{st-x+1}$), respectively. Since both years should not have an influence on the students, any significant effects would be due to selection. The school-fixed effects and the school-specific cubic time trends should control for any unobservable school characteristics that are correlated with the share of female students as well as the choice of school type in grade 9. However, there is still some space for endogeneity if those unobservable characteristics change over time and left untouched by the school specific time trends.

The share of girls in grade 5 is not observable to parents and kids when they enroll in a certain school, thus, $Girls_{st-x}$ should be exogenous. Though, students with preferences for female or male dominated classrooms may decide for a school with a certain share of girls in the previous period. On the other hand, a new school campaign starting in a given year might have lagged effects on the share of females in the next period.

Table 7: Effects of *Girls* - Placebo treatments

	Unweighted		Weighted		
Binary Models	LPM (Coef)	Logit (ME)	LPM (Coef)	Logit (ME)	N
Female weak					
Girls_{st-x-1}	0.231	0.273	0.205	0.241	2,856
	(0.154)	(0.182)	(0.158)	(0.188)	
Girls_{st-x+1}	0.046	0.050	0.015	0.020	2,826
	(0.175)	(0.201)	(0.176)	(0.202)	
Female					
Girls_{st-x-1}	0.216	0.217	0.183	0.180	2,856
	(0.149)	(0.163)	(0.144)	(0.160)	
Girls_{st-x+1}	0.110	0.109	0.120	0.122	2,826
	(0.146)	(0.154)	(0.151)	(0.160)	
	Unweighted		Weighted		
Ordered Models	Ordered Logit (Coef)		Ordered Logit (Coef)		N
Ordered					
Girls_{st-x-1}	0.977		0.801		2,856
	(0.658)		(0.641)		
Girls_{st-x+1}	0.189		0.253		2,826
	(0.658)		(0.673)		
Ordered detail					
Girls_{st-x-1}	0.912		0.813		2,856
	(0.596)		(0.603)		
Girls_{st-x+1}	0.187		0.016		2,826
	(0.633)		(0.662)		

NOTES: Each coefficient and marginal effect represents a separate regression. School-fixed effects, school-specific cubic time trends, age, foreign, grade size, missing dummy for foreign included in all regressions. Heteroscedasticity and cluster-robust standard errors in parentheses (clusters are school-years). Weighted regressions: Weight = 1/Girls. ***, ** and * indicate statistical significance at the 1-percent, 5-percent and 10-percent level.

The estimates are based on the grade 5 sample and given in table 7. For both placebo treatments, the number of observations is smaller because Girls_{st-x-1} is not available for the first cohort and Girls_{st-x+1} for the last cohort. Due to space considerations, the coefficients of the ordered logit regressions are shown instead of the marginal effects. Each estimate has a positive sign and none of them is statistically significant. These results strongly support our identification strategy.

5.2 Are male-dominated school types better schools?

As the placebo treatments show, our estimates are not driven by selection effects and can be interpreted as causal. However, what is the mechanism behind these results? Is it true, that female students choose the technical school type more often because they establish a higher level of self confidence in male-dominated subjects if they are in female classes or are the results driven by confounding factors?

Hoxby (2000) as well as Lavy and Schlosser (2007) found that a higher share of female students has a positive impact on cognitive achievement of boys and girls. If female domination of school types is negatively correlated with achievement levels, the underlying mechanism might be a different one and the results would be driven by unobserved achievement effects.

Two different strategies are used to investigate this potential problem. First, we use PISA data to show how the applied classification of school types into female and male-dominated ones, is related to student achievement levels. Second, we use boys as a control group. If the results are driven by unobserved achievement effects, the estimates should be similar for male students.

Figure 4 shows the mean PISA test scores in mathematics, reading and science of Austrian students in the various school types. The school types are ranked by the mean test score over all subjects.

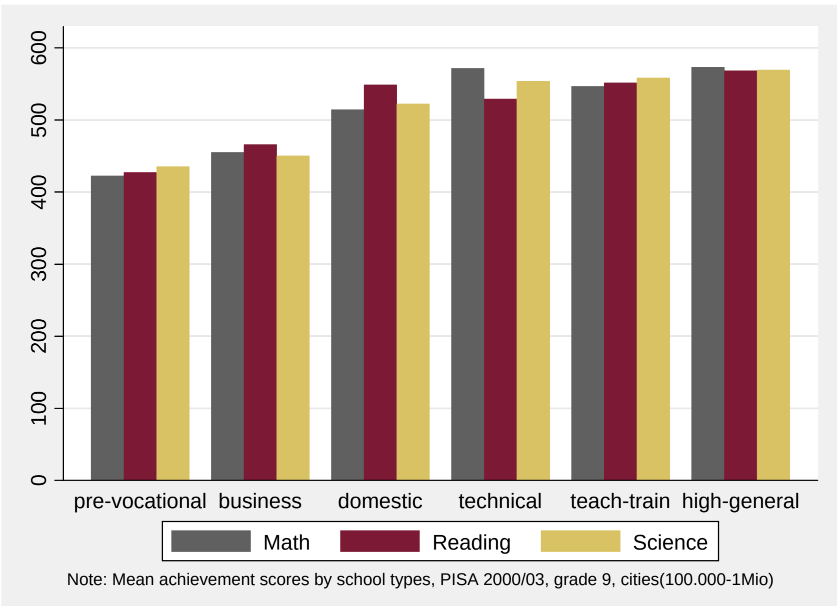

Figure 4: PISA achievement levels and school types

Students in pre-vocational and business schools achieve significantly lower test scores than those in the other school types. In both binary models, the pre-vocational track is classified as male school type and business schools are classified as female school types. In the ordered models, the pre-vocational school is either neutral or weakly male dominated and business schools are female or weakly female dominated. The highest PISA scores are achieved by students in higher general schools, which are classified as weakly female dominated or neutral school types. The graph suggests that female and male-domination does not correspond with achievement levels.[13]

If the results were driven by achievement effects, females in classes with a higher proportion of girls would choose the pre-vocational track and the business schools less often. Table 8 shows that this is not the case.

Table 8: Effects of *Girls* - Pre-vocational and business schools

	Unweighted		Weighted		
Effect of *Girls*	LPM (Coef)	Logit (ME)	LPM (Coef)	Logit (ME)	N
Pre-vocational and business					
Grade 5	0.135	0.140	0.153	0.160	3,046
	(0.157)	(0.178)	(0.163)	(0.187)	
Big Sample	0.193	0.205	0.207	0.220	3,366
	(0.144)	(0.164)	(0.147)	(0.168)	

NOTES: Each coefficient and marginal effect represents a separate regression. School-fixed effects, school-specific cubic time trends, age, foreign, grade size, missing dummy for foreign included in all regressions. Big sample includes g6-g8 dummies. Heteroscedasticity and cluster-robust standard errors in parentheses (clusters are school-years). Weighted regressions: Weight = 1/Girls. ***, ** and * indicate statistical significance at the 1-percent, 5-percent and 10-percent level.

For our second falsification test we use boys as control group. Hoxby (2000) and Lavy and Schlosser (2007) found that the fraction of girls has a positive impact on the cognitive achievement of boys and girls. If our results were driven by achievement effects and not gender identity effects, the classification of school types would capture a hidden achievement classification, and this would apply for boys as well. The estimates for boys are given in table 9.

Again, the estimated coefficients of the ordered logit models are given instead of marginal effects. None of the coefficients and marginal effects is statistically significant. Male students are not influenced by the share of girls in their choice of school type, when schools are categorized as male- and female-dominated ones.

[13]We calculated mean PISA scores (math, science, reading, the mean over all subjects and a PISA achievement rank variable) for each school type and correlated them with our various definitions of female-domination, both binary and both ordered variables. None of the correlation coefficients is statistically significant and the sings vary across definitions of female-domination. For example, the correlation coefficient for the mean PISA score over all subjects and female school types is -0.019, for weakly female-dominated school types +0.307, for the 3-category ordered variable -0.180 and for the 5-category ordered variable +0.127.

Table 9: Effects of *Girls* - Results for boys

	Unweighted		Weighted		
Binary Models	LPM (Coef)	Logit (ME)	LPM (Coef)	Logit (ME)	N
Female weak					
Grade 5	0.059	0.071	0.097	0.106	3,723 &
	(0.111)	(0.097)	(0.121)	(0.100)	3,717
Big Sample	0.075	0.079	0.118	0.120	4,106 &
	(0.105)	(0.093)	(0.116)	(0.099)	4,094
Female					
Grade 5	0.086	0.081	0.127	0.113	3,723 &
	(0.082)	(0.067)	(0.090)	(0.069)	3,717
Big Sample	0.099	0.082	0.146	0.120	4,106 &
	(0.084)	(0.069)	(0.093)	(0.073)	4,094

	Unweighted	Weighted	
Ordered Models	Ordered Logit (Coef)	Ordered Logit (Coef)	N
Ordered			
Grade 5	-0.142	0.074	3,723
	(0.566)	(0.643)	
Big Sample	-0.119	0.127	4,106
	(0.547)	(0.622)	
Ordered detail			
Grade 5	-0.172	0.063	3,723
	(0.563)	(0.662)	
Big Sample	-0.137	0.122	4,106
	(0.531)	(0.632)	

NOTES: Each coefficient and marginal effect represents a separate regression. School-fixed effects, school-specific cubic time trends, age, foreign, grade size, missing dummy for foreign included in all regressions. Heteroscedasticity and cluster-robust standard errors in parentheses (clusters are school-years). Weighted regressions: Weight = 1/(1-Girls). ***, ** and * indicate statistical significance at the 1-percent, 5-percent and 10-percent level. For the binary logit estimations 3,717(4,094) observations are used. The missing dummy for foreign background predicts the outcome perfectly and those 6(12) observations with missing information on native tongue are dropped from the sample.

5.3 IV Estimations

The share of females in grade 5 is exogenous because the students and their parents do not observe the gender composition when they enroll in the school. From grade 6 to grade 8, gender composition might be endogenous if students change schools on the basis of unobserved characteristics that are correlated with the share of females (and not captured by the school fixed effects and the school-specific cubic time trends). However, the share of girls in grade 5 might be less important for the choice of school type than the share of girls in other grades later on, e.g. grade 8.

To meet these concerns, we estimate an additional model, using gender composition in grade 5 as instrument for gender composition in grade 8. The identifying assumption is that the gender composition in grade 5 is related to gender composition in grade 8 but has no separate effect on the dependent variable. We assume that our previous estimates for grade 5 are reduced form estimates and are driven by students for whom the gender composition was relatively constant between grade 5 and 8. Our previous estimates should be regarded as lower bounds because for some students, the correlation of the share of females in grade 5 and grade 8 is low, e.g. grade repeaters and school movers face different environments. Table 10 gives results for the binary linear probability models.

Table 10: Effects of *Girls* - IV Estimates

	Female weak		*Female*	
LPM (Coef)	unweighted	weighted	unweighted	weighted
Grade 5	-0.339	-0.391	-0.459	-0.514
	(0.166)**	(0.168)**	(0.138)***	(0.140)***
Grade 6	-0.321	-0.365	-0.426	-0.480
	(0.174)*	(0.176)**	(0.144)***	(0.145)***
Grade 7	-0.287	-0.330	-0.388	-0.461
	(0.174)*	(0.174)*	(0.150)**	(0.152)***
Grade 8	-0.241	-0.325	-0.368	-0.465
	(0.166)	(0.167)*	(0.146)**	(0.150)***
IV (Grade 8)	-0.408	-0.486	-0.549	-0.636
	(0.197)**	(0.200)**	(0.165)***	(0.171)***
First stage	0.836	0.829	0.836	0.829
	(0.031)***	(0.029)***	(0.031)***	(0.029)***
F-Statistics (first stage)	141.0	141.0	136.3	136.3
Observations	2,808	2,808	2,808	2,808

NOTES: Each coefficient represents a separate regression. School-fixed effects, school-specific cubic time trends, age, foreign, grade size, missing dummy for foreign included in all regressions. IV: gender composition in grade 8 is instrumented with gender composition in grade 5. Heteroscedasticity and cluster-robust standard errors in parentheses (clusters are school-years). Weighted regressions: Weight = 1/(1-Girls). ***, ** and * indicate statistical significance at the 1-percent, 5-percent and 10-percent level.

First, regressions for the grades 5-8 are shown.[14] When using higher grades, the estimates get smaller in magnitude and lose precision. The results are consistent with the results of the placebo treatments, suggesting that the potential endogeneity bias goes in the opposite direction.

The instrumental variable regressions as well as the first stage estimates are also given in table 10. The first stage is powerful, the estimates as well as the F-Statistics show that the fraction of girls in grade 5 is a strong instrument for the fraction of girls in grade 8. The IV estimates for female dominated school types range from -0.55 to -0.64, i.e. an increase in the share of girls in grade 8 by one standard

[14]Note that the sample is a bit smaller because it consists of all students who are observed during the grades 5-8 and didn't change school. We use a constant sample over all grades to ensure the comparability of our estimates.

deviation will reduce the probability for girls to attend a female dominated school type by 6-7 percentage points. The IV estimates give the effect for compliers, those students who are exposed to a relatively similar share of girls throughout the grades 5 to 8.

6 Conclusion

Many studies in educational science show that girls are doing better in male-dominated subjects like math and science, and are more likely to choose those subjects, if they are educated in female classes. Coeducational settings appear to reinforce gender-stereotypes, while single-sex schooling gives more freedom in exploring interests and abilities, especially for female students.

In this paper, we estimate the causal impact of gender composition in coeducational schools on the choice of school type for female students. The Austrian education system consists of a variety of intermediate and higher vocational school types with different orientations, some of which are traditionally female-dominated, like schools for domestic sciences, and others are male-dominated, like technical schools. We use register data of 19 cohorts of compulsory school students from Linz, the third largest city in Austria. Identification is based on population variation, i.e. the natural variation in the share of girls of adjacent cohorts within schools.

Our results show that female students choose the female-dominated school types less likely and the technical school type more likely if they were exposed to a higher share of girls. The magnitudes of the effects are sizeable, even though the IV estimates indicate that they should be regarded as lower bounds. Although an extrapolation of our estimates is problematic, a shift to single-sex schooling would decrease the probability for female students to end up in a traditionally female dominated school type by about 24%-points. Furthermore, the share of female students in technical schools would increase by 1%-point. Given the low fraction of girls in such schools, on average 5% between 1979 and 2002, a 1%-point increase can be regarded as relatively high.

Occupational segregation of men and women in the labor market is an important determinant of gender differences in wages. If policy is targeted at providing equal opportunities in the labor market, education policy and the question of coeducation versus single-sex schooling with its consequences for female occupational choices is important. This study has shown, that the fraction of girls is a crucial determinant of the choice of school type for female students and the results are not driven by selection effects or unobserved achievement effects. It seems that female students establish a higher degree of self-confidence in male-dominated subjects if they are in classes with a higher share of female students. The results are in line with other economic studies in this field and research in psychology or educational science.

However, many questions about single-sex schooling are still not answered: What are the effects on overall achievement for boys and for girls? And if separation is optimal, on what level should we introduce single-sex classes, at the school-level, the class-level or only in certain subjects? More economic research is needed in this field to find an optimal design of the education system with regard to coeducation and single-sex schooling.

A Appendix: Missing values

We do not observe the school choice in grade 9 for about 59% of low track students. For most of these cases, there is an explanation why the information is missing in the data. Part of the students drop out of fulltime education after grade 8 if they have already completed 9 years of schooling due to pre-school or grade repetition.

In the school year 2006/07, the percentage of drop outs after grade 8 was about 15% in Austria and 20% in Vienna (Statistik Austria, 2008). Even if the students do not drop out, the municipality of Linz may not report their school choice in grade 9 if the students have already completed 9 years of schooling. Reporting 9 years of compulsory schooling for each student is the single purpose of the data collection by the municipality.

In our data, the majority of students with missing values in grade 9 has attended preschool or repeated a grade. For only 23% of all students the information is missing due to unknown reasons. Furthermore, our data is incomplete concerning grade 9 due to unknown reasons in 3 years, the grade-5-cohorts in 1989-1991. When these years are ignored, the percentage of missings without any explanation drops to 15%. The results of all estimations presented in this paper are robust to the exclusion of the grade 5 cohorts 1989 to 1991.

Table 11 shows summary statistics in grade 5, for both, those students who are observed in grade 9 and those who are not observed. The latter students are somewhat older because many of them attended pre-school or repeated a grade and the fraction of students with migration background is higher. While about 18% of our estimation sample attended a pre-school or repeated a grade, this percentage is about 65% for the students with missing values. Most importantly, whether we observe a student in grade 9 is not related to the fraction of girls in grade 5.

Table 11: Summary statistics of Non-missing and Missing students in grade 9

	Summary statistics Grade 5			
	Grade 9 Non-Missing		*Grade 9 Missing*	
Variables	Mean	Stdev	Mean	Stdev
Student-level variables				
Female	0.450		0.434	
Age in grade 5	10.671	0.406	11.132	0.670
Foreign language	0.111		0.169	
Grade-level variables				
Grade size	57.784	17.172	57.841	17.213
Fraction of girls	0.436	0.114	0.439	0.115
Preschool and grade repetition				
Preschool	0.134		0.354	
Grade repetition	0.049		0.301	
Number of observations	6,769		9,847	
Number of low track schools	18		18	

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