Peer Effects in Austrian Schools

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Abstract

This study deals with educational production in Austria and is focused on the potential impact of schoolmates on students' academic outcomes. We used PISA 2000 data to estimate peer effects for 15 and 16 year old students. The estimations yield substantial positive effects of the peer groups' socioeconomic composition on student achievement. Furthermore, quantile regressions suggest peer effects to be asymmetric in favor of low-ability students, meaning that students with lower skills benefit more from being exposed to clever peers, whereas those with higher skills do not seem to be affected much. Social heterogeneity, moreover, has no big adverse effect on academic outcomes. These results imply considerable social gains of reducing stratification in educational settings.

1 Introduction

Economics of education deals with the explanation of academic achievement of students. Some of the determinants of cognitive development, like individual inputs, parental counseling and "good parenting" can not be influenced much by public policy, the use of school resources can. Typical discussions about school resources concern the education and pay of teachers as well as class size effects. Whereas the evidence on the effects of class size is somewhat mixed[1], many studies suggest that organizational changes in schools can have sizeable effects on academic achievement.[2]

Among organizational changes, the composition of classes is internationally one of the most studied topics. The starting point is the assumption that children do not only learn from their teachers but from class- and schoolmates, too. The peer group can be important directly, by talking, learning in groups and helping one another and indirectly, via observational learning. Peers often act as role models, which are seen as powerful means of transmitting attitudes, values, norms and patterns of thought and behavior (Bandura, 1986).

The impact of the peer group on academic achievement – the peer effect – is the main issue in this study. The magnitude and nature of peer effects may affect the optimal organization of schooling. The question whether to segregate students in different schools and classes or to prefer a more integrating education system can perhaps be answered via analyzing social interactions among students. The most important question to be answered is: "Should high-ability students be grouped together or should they be spread evenly among schools and classes?" Proponents of an integrative education system claim that less gifted students need the presence of clever peers to stimulate learning, whereas opponents argue that such systems make it difficult to target differing needs of students and handle class-management.

Peer effects need not be equal for all students. If asymmetric peer effects can be detected in the way that low-ability students are more influenced by their peers than good students, a decrease in educational stratification will increase the total amount of learning, and reshuffling students will be an issue of economic efficiency. If the asymmetry goes the other way around, and high-ability students are more sensitive to peers, segregation will be the optimal policy. If peer effects are symmetric, a reallocation of students will be a question of distribution, only.

Recent research on school tracking and segregation assesses the advantages and disadvantages of early segregation in schools according to abilities. Brunello et al. (2004) found that there is a trade-off between returns to specialization on the labor market, which would call for an early tracking and the

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[1] See for example the discussion between Hanushek (2002) and Krueger (2002).
[2] See for example Wößmann (2003a), Betts (1998).

costs of early selection, which are basically costs of erroneously allocating students and less general education as such.

In this study we want to shed some light on the magnitude of peer effects relative to other schooling inputs as well as to find out whether the peers' influence is symmetric or asymmetric[3]. In doing so, an educational production function is estimated for Austria with data from PISA 2000. In detail, we address the following questions for students in Austrian secondary education: Do peer groups have a measurable effect on student achievement? Is it that students with less favorable home environments and low-ability students are more reliant on their peers? Are academic outcomes affected adversely by social heterogeneity? Are there differences between the subjects reading and mathematics/science?

The paper proceeds as follows. Section 2, preliminary deals with the definition of peer effects and reviews previous economic studies in this field. Section 3 represents the empirical framework, containing identification strategies, a description of the data set and sampling process and the incorporated methodologies. The estimated results are described and interpreted in section 4, and finally, section 5 concludes.

2 The Identification of Peer Group Effects

Charles Manski (1995, 2000) described a framework for a systematic analysis of social interactions. He stated three hypotheses, regarding the phenomenon that individuals belonging to the same group tend to behave alike:

- **Endogenous effects** The probability that an individual behaves in some way is increasing with the presence of this behavior in the group; student achievement depends positively on the average achievement in the peer group.

- **Contextual effects** The probability that an individual behaves in some way depends on the distribution of exogeneous background characteristics in the group; student achievement depends on the socioeconomic composition of the peer group.

- **Correlated effects** Individuals behave in the same way because they have similar background characteristics and face similar environments; student achievement is correlated within the group because students come from similar home environments and are instructed by the same teachers in the same schools.

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[3] Implicitly, we focus, as many other economic studies do, on cognitive development of students only, other aspects of education, like social learning are disregarded. Good reason can be made that exposure to students from different backgrounds – be it disadvantaged or handicapped classmates – could improve social skills in particular.

Endogenous and contextual effects are driven by social interactions, whereas correlated effects are a non-social phenomenon. It is important to distinguish between endogenous and contextual effects. Positive contextual effects mean that an individual student *i*'s achievement will rise if a classmate *j* with a performance furthering background arrives. In the case of endogenous effects, the interaction is not completed yet; the actual increase in achievement of student *i* will further the achievement of student *j* – there are repercussions, a multiplier effect. For social and educational policy it would therefore be important to know, if by individually enhancing the cognitive performance of one student in class, the achievement of the classmates would be furthered automatically. Unfortunately, contextual and endogenous effects cannot be separated empirically because background characteristics of student *i* are causing student *i*'s achievement: a perfect multicollinearity. Moreover, the investigation of endogenous effects causes a classical simultaneity problem because mean achievement of the group is taken as regressor but achievement in the group itself is influenced by the achievement of the student in question. In our study, we only estimate contextual effects – effects of the peer groups' socioeconomic composition on student achievement – to circumvent these problems.

Another problem concerns self-selection of students into schools and peer groups. If better students choose a better school and peer group, peer effects will be overestimated. The Austrian school system does allow the choice of school type and school but not the choice of class within a school. Students (and their parents) choose at the age of 10 and at the age of 14 which school type they will attain. Our strategy therefore is twofold: first, we try to include rich information on the students' family backgrounds to reduce the omitted variables bias, and second, we introduce school type fixed effects because the selection of students in Austria is mainly based on school type.

Several empirical studies have been carried out to measure peer effects in pirmary and secondary education (Schindler-Rangvid, 2003, Fertig, 2003, McEwan, 2003, Levin, 2001, Betts and Zau, 2004, Hanushek et al., 2003, Hoxby, 2000, Vigdor and Nechyba, 2004, Robertson and Symons, 2003, Angrist and Lang, 2004) as well as in higher education (Sacerdote, 2000, Winston and Zimmerman, 2003, Arcidiacono and Nicholson, 2003). Most of the studies found sizeable positive effects of school- or classmates on student achievement, whereat these effects were found to be somewhat stronger at class level.

Some studies deal with the question of whether peer effects are asymmetric. Schindler-Rangvid (2003) found peer effects to be stronger for weaker students in Denmark. Levin (2001) found stronger effects for weaker students in the Netherlands. Sacerdote (2000) and Winston and Zimmerman (2003) also found some evidenve for non-linearities, mostly in favor of low-ability students in US higher education.

The question of heterogeneity was addressed by some economists, too. The results are ambiguous, Schindler-Rangvid (2003) found no significant effects of social heterogeneity in Denmark, Fertig (2003) found some negative impact of ability dispersion for the USA and Vigdor and Nechyba (2004) found positive effects of ability disperson for students in North Carolina.

Peer effects were also investigated in other fields of research, like teenage behavior (Kooreman, 2003, Soetevent and Kooreman, 2004), juvenile delinquency (Bayer et al., 2004) or youth smoking (Krauth, 2001, 2004, Eisenberg, 2004). An interesting experiment on peer effects in work productivity was carried out by Falk and Ichino (2003). The authors found significant peer effects and, furthermore, low productivity workers to be more sensitive to the behavior of peers.

3 Empirical Framework

The empirical analysis is based on data from PISA 2000, the Program of International Student Assessment conducted by the OECD. 15 to 16 year old students, reaching the end of compulsory schooling in most industrialized countries, were tested in reading, mathematics and science, and additionally, detailed background information about students and schools was collected. In total, 4,745 Austrian students out of 213 schools and 19 school types were assessed for PISA[4].

We estimate peer effects using a standard model of educational production, in which the outcome of education, the PISA result, is estimated as a function of the students' individual characteristics, family background indicators, school specific inputs and peer group attributes. The model can be written as

$$Y_{isg} = \beta_0 + \beta_1 X_{isg} + \beta_2 S_s + \beta_3 P_{-isg} + \varepsilon_{isg},$$

where Y_{isg} is educational outcome of student *i* in school *s* in grade *g*, X_{isg} is a vector of individual and family characteristics, S_s represents school resources and institutional features characterizing school *s*, P_{-isg} is peer characteristics without the contribution of student *i* and ε_{isg} is the unobserved error term , including for example innate ability and motivation.

A critical point in measuring the influence of the peer group is the fact that there is no information about the "real" reference group of a student. As we cannot directly identify the friends of the student in question, we have to assume that students are significantly influenced by their classmates, keeping in mind that students spend a relatively big part of their time at school. The studies of Kooreman (2003) and Soetevent and Kooreman (2004) indicate that classmates are important in determining high school teen behavior. Especially for types of behavior closely related to school (e.g. truancy) peer effects are strong.

[4] For detailed information on the PISA survey design and sampling see OECD (2002).

Unfortunately, PISA does not contain information about classes. Thus, the peer group in our study is defined as students attending the same school and grade. In Austria, within a school ability grouping across classes is not common; therefore, the student composition within a grade in a particular school should be a good proxy for the composition in classes. Nevertheless, the problem should not be understated and we expect the estimated peer effects to be smaller than in empirical research where students can be matched with their classmates. Betts and Zau (2004) and Vigdor and Nechyba (2004) showed that the analysis of peer effects at class level yield stronger effects compared to the grade level.

As mentioned above, due to the simultaneity problem and the problem of self-selection of students to schools and peer groups, the peer groups' contribution is not easily identified. Our strategies to handle these issues are, first, not to use PISA achievement as a peer quality indicator but the peer groups' socioeconomic composition, which is in part a proxy for attitudes and learning related activities. And second, the endogenous nature of the peer group itself is addressed in two ways. The omitted variables bias can be significantly reduced by using a number of powerful explanatory variables affecting both, academic achievement and peer group formation. Furthermore, a school type fixed effects model is implemented. In Austria's differentiated education system, self-selection is mainly driven through the segregation of students in different school types. Students attending the same school type have decided in a similar manner, and it can be assumed that these students and their parents share unobserved characteristics. Controlling for school types, thus, would significantly reduce the bias.

In selecting the sample for the study from the whole PISA sample, we focused on several criteria. First, peer groups are based on students attending the same schools and grades, thus, students with missing grade values were excluded from the sample. Second, to represent peer quality, two indicators of the students' family background are used and students with missing values of these major explanatory variables were dropped. Third, since the peer quality is represented by mean characteristics of a student's peers, we restricted the sample to peer groups of at least 8 students. The size of the peer group varies between 8 and 32 students, with the mean peer group consisting of about 17 students. Fourth, the PISA students belong to a variety of different school types, whereat some school types were totally excluded from the sample. Students attending special schools were omitted to ensure comparability and students attending the so called 'Berufsschulen' were dropped. 'Berufsschulen' are part time schools for apprentices and we suppose to find the real reference group of these youths more likely in the firms they are employed or in their neighborhoods, rather than at school[5]. Finally, students attending the 8th grade were discarded because in Austria 15 to 16 year old students are normally not attending grade 8 unless they are repeating the class.

[5] The apprentices approximately spend one full day a week at school in addition to learn their vocation by working in a firm.

The final sample includes 3,251 observations. The major domain in the PISA 2000 wave was reading literacy, therefore, $^2/_3$ of all test questions focused on reading topics and all 3,251 Austrian students were assessed in reading. Only $^1/_6$ of all questions covered mathematics and $^1/_6$ science issues[6]. To infer potential differences across subjects we created a maths/science sample, where students' records in mathematics, in science or a mean of maths and science scores are reported. The maths/science sample contains 2,825 observations.

Table 1 gives a detailed description of the used variables as well as summary statistics for the reading sample. The PISA data set provides rich information to represent the students' family background as well as school environment. The dependent variables are student achievement in reading and in maths/science. As each test consists of a battery of questions, the actual score can not be observed directly. PISA used an item response scaling model, therefore, students' proficiencies must be inferred from the observed item responses. Warm's weighted likelihood estimates (WLE) are utilized in PISA and represent the score the students attained most likely[7]. Additionally to the WLE, the standard errors of these are provided. The PISA team has transformed the WLE to a mean of 500 and a standard deviation of 100, by using data from all OECD countries, except the Netherlands[8].

Peer quality is modeled either as the peers' *socioeconomic index of occupational status* or as their *index of cultural communication at home*. We use both variants of peer indicators by turns to answer our research questions. The socioeconomic status was derived from students' reports on parental occupations and ranges from 16 to 90, lower values indicate a lower socioeconomic status[9]. The index of cultural communication at home should also represent the students' home environment and was derived from the frequency with which the students and their parents engage in the following activities: talking about political or social issues, films or TV programs and listening to classical music. The index was standardized to a mean of 0 and a standard deviation of 1 over all OECD-countries, except the Netherlands. These two indices outperform categorical or dummy variables. In particular, they outperform the educational level of parents because PISA provides ISCED categories, which do not fit the Austrian education system well, and valuable information is lost in this compression.

In a first step, survey interval regressions are used to estimate educational production functions and to measure the mean effect of peer quality on students' academic outcomes. The survey estimation technique is used because it takes into account that the sample is not random, but product of a complex

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[6] The PISA project proceeds in several cycles. The first wave in 2000 focused on reading, whereas in 2003 and 2006 the other topics will be central.
[7] For more information on Warm's weighted likelihood estimate see OECD (2002).
[8] For a detailed analysis of PISA achievement across the participating countries see OECD (2001), for information on Austria's performance in PISA see Haider et al. (2001).
[9] The index is described in detail in Ganzeboom, DeGraaf and Treiman (1992).

stratified sampling procedure. To assure representativeness, three design effects are considered. First, student weights are employed accounting for differences in sampling probabilities[10]. Second, the methodology takes into account that variations among students from the same school may be smaller than between schools by estimating cluster robust standard errors. And third, sampling has been done independently across strata, therefore, the strata are statistically independent and can be analyzed as such. In many cases, this will lead to smaller standard errors.

Furthermore, we adopt interval regression techniques because the dependent variable itself is an estimate. Instead of using the point estimate only, we employ an interval as dependent variable. The size of the interval was chosen to be of two standard errors, starting from the mean WLE, one standard error in both directions. The model ist estimated with Maximum Likelihood.

The survey interval regression, like OLS does, is designed to estimate mean effects, hence, the effects of explanatory variables for the average student. By estimating peer effects with quantile regressions, one can estimate different effects for different students on the conditional test score distribution (Koenker and Bassett, 1978). All observations are used and the effect for different quantiles is estimated by weighting the residuals differently, depending on the quantile in question. Robustness to potential heteroscedasticity can be achieved by bootstrapping methods, in which the standard errors are obtained by resampling the data. We employed 200 bootstrap replications in this study.

4 Results

The following section describes the empirical results. Section 4.1 deals with mean peer effects and gives an account of the basic model used in all further estimations. In the next section, the hypotheses that low ability students and students out of less learning stimulating home environments are more reliant on their peers are tested. Finally, section 4.3 addresses the question whether students are adversely affected by social heterogeneity in the peer group.

4.1 Mean Peer Effects

Table 2 gives the estimated effects of peers and individual, family and school characteristics on reading and maths/science achievement. The mean socioeconomic status of the peer group and the mean index of cultural communication at home are used as peer quality indicators.

In reading, the mean *socioeconomic status of peers* and the mean index of *cultural communication with parents* show considerable positive effects. For example, moving a student to a new peer group

[10] Probabilities of being sampled were not equally distributed but dependent on the specific school type a student attends and the region the school is located.

with a one standard deviation higher socioeconomic index, all else equal, will rise the student's reading achievement level by 5.1 points on the PISA scale[11]. The peer effect is even larger if cultural communication at home is used to characterize the peer group. A one standard deviation increase of cultural communication of peers increases student achievement by 8.6 points, or 10 percent of the standard deviation of reading test scores. In mathematics and science, the peer effects are smaller and the socioeconomic status of the peer group gets statistically insignificant[12]. It seems that social interactions with schoolmates are more influential for developing reading literacy than proficiency in maths and science.

Besides the peer group, the effects of the other variables should also be mentioned. The majority of individual characteristics show the expected effects. Females perform better in reading and male students in mathematics and science. Grade is clearly an important predictor of achievement; students attending the 10th grade perform better than students in the 9th one. Living in a single parent family has not the expected negative effect. Compared to nuclear families, where students live with both parents, the estimates suggest that these students perform better in both subjects[13]. Furthermore, the number of siblings enters the model in level and in quadratic form, and the optimal number of siblings is about 2.6 in reading and 2.2 in maths/science. Immigrants and students with immigrated parents perform considerably worse than ethnic Austrians.

The students' family background indicators show important effects, especially in reading. The family's socioeconomic status, cultural communication with parents, books at home and what the parents are doing have the expected effects. The mother's education level is a common predictor of educational achievement, but once corrected for socioeconomic status, the variable has no separate effect any more. Specifications with father's education are even less significant.

Most family background characteristics show stronger and statistically more significant effects in reading, than in maths/science. This finding is consistent with the estimated peer effects, which are also more important for reading literacy.

Compared to individual characteristics and family background, school resources and institutional features are less important; some effects are found for school size and teacher behavior. The number of

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[11] To be correct, such a treatment would raise the student's interval (lower and upper bound) in which his or her "real" proficiency lies by 5.1 PISA points. In the following, we omit the correct expression, to simplify the interpretation of the regression output.

[12] P-value: 0.25

[13] Previous studies on family structure and academic achievement yield no clear results. Mahler and Winkelmann (2004) found a negative effect of a single-parent family structure on educational attainment in Germany, which disappears when the family's socioeconomic background is controlled for. Furthermore, Wößmann (2003) found different effects in different countries, whereby in most countries, like Germany, intact families have positive effects on student achievement. In Austria, intact family has a negative insignificant effect.

students per teacher has no significant effect[14]. The result that the family background is more important than school characteristics is in line with other studies of educational production; see for example Hanushek and Luque (2003) and Wößmann (2003)

School type dummies, in contrast, are highly significant. We found the largest negative effects for students in the pre-vocational schools 'Polytechnische Schule' and in the intermediate vocational schools 'Berufsbildende Mittlere Schule'. They perform about 90 points and about 70 points worse, compared to students in the higher general schools 'Gymnasium'. Altogether, the segregative school system of Austria is reflected in the large and statistically significant effects of school types on academic outcomes. Implementing a school type fixed effects model when studying peer effects should, therefore, produce more robust estimates.

To sum up, substantial peer effects exist and social interactions either at home with the parents or at school with schoolmates have more impact on reading achievement than achievement in maths/science.

4.2 Asymmetric Peer Effects

The peer group does affect student achievement positively, at least in reading. This seems more like a trivial result: nobody would have expected a negative effect; the learning environment for the mean student does not get worse, if he or she is around clever students. Raising peer quality for every student is an impossible task, though. From a policy point of view, the more relevant questions are concerned with distributional issues: *For whom does the peer group matter most? Are students from less supportive families more influenced by their peers? Do clever students or weaker students profit more from being confronted with clever peers*? To address these issues two hypotheses are tested:

1. Students out of less favorable home environments are more dependent on others in their learning, and therefore, more influenced by their peer group.

2. Low achieving students with a larger cognitive distance to their peers profit more from good students because more can be learned when levels are low. On the other hand, low achieving students could be less affected because observational learning from peers as well as a healthy competitive learning climate perhaps requires similar cognitive abilities.

To test the first hypothesis, we estimated two models allowing for decreasing peer effects with rising own socioeconomic status and rising own index of cultural communication. The relevant coefficients are presented in table 3. It is interesting to note that the signs of all four interaction terms support our

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[14] For a detailed discussion on class size effects see Hanushek (1997, 1998, 2002), Krueger and Whitmore (2001) and Krueger (2002).

hypothesis; however, the statistical significance is rather low (20%, 6%, 15% and 32%). Only specification (2) supplies clear evidence that students with a higher index of cultural communication at home are less sensitive to peer characteristics.

A related non-parametric strategy is to divide students into three categories, concerning their own family background: top, middle and bottom students[15]. We then allowed the peer effect to be different for each category. Table 4 shows the estimated peer effects which corroborate our results from above. When using the socioeconomic status as relevant family background indicator the peer effects are not different for students from different backgrounds. The index of cultural communication with parents as quality measure yields asymmetric peer effects: bottom students are more affected than top or middle students. F-tests show that the peer effects are statistically different for bottom and middle students at the 3.6 % level in reading. In maths/science the peer effect is just statistically significant for bottom students only.

To demonstrate the different magnitudes, imagine an increase in peer quality of 0.36 points (one standard deviation) of the mean index of cultural communication in the peer group. A student, located in the bottom of the distribution, will benefit with an increase of about 11 PISA reading points. Another student, located in the middle category, will benefit only with an increase of about 6 points. Thus, the peer effect is almost twice as high for low family background students. Additionally, this increase in peer quality will raise the bottom students' maths/science scores by 7 points.

All in all, students with a low level of cultural communication at home can achieve higher returns in academic achievement from a peer group with a high level of cultural communication at home. The evidence for the first hypothesis is weaker when drawing on socioeconomic status as relevant variable and when estimating effects for maths/science.

It is worth noting that these results are robust to alternative estimation methods. Using survey interval regressions and increasing the interval of the dependent variable to 1.96 standard deviations in both directions, thus, covering the 95th percent confidence interval, yield the same results. The peer effects as well as the other results do even not differ, if we ignore the uncertainty of the dependent variable and estimate the model with weighted and cluster robust least squares.

The second hypothesis is tested with quantile regression analysis, allowing peer effects to vary for students with different cognitive abilities, according to the PISA scale. Estimates are reported for the 15th, the 25th, the 50th, the 75th and the 85th percentile of the conditional test score distribution. Table 5 shows the estimated effects for each quantile. It appears that students in the lower part of the

[15] Socioeconomic status: top students are students above the 67th percentile, bottom students are those up to the 35th percentile; Cultural communication: top students are students above the 71st (72nd percentile in maths/science) and bottom students are those up to the 32nd percentile; the discrete nature of the parameter values impeded an exactly equal distribution.

distribution are more affected by their peers, compared to high-ability students. Each regression, except specification (2), shows a declining economic and statistical significance along the conditional test score distribution, and students in the 75^{th} and 85^{th} percentile are not affected at all.

In terms of public policy, the results suggest that a more equal allocation of high-ability students across schools may yield a higher level of achievement and, furthermore, a pareto-improvement. Low ability students can substantially benefit from a high quality peer group, whereas high-ability students are not influenced.

Social gains from reallocating students are only true if there is no separate and adverse effect of social heterogeneity in schools and classes. Students may be influenced not only by the mean level of peer quality but by the diversity of the peers as well. Thus, the effect of social heterogeneity on academic achievement is tested by introducing the standard deviation of the peer quality variable in question. Table 6 shows coefficients from quantile regressions. Out of 16 coefficients for heterogeneity of the peer group, only two show a significant negative sign. In specification (2) some negative effects for students located in the 50^{th} percentile can be seen and in specification (4) some effects for students in the 85^{th}. However, the whole picture does not argue for large disadvantages of heterogeneity.

5 Conclusion

In this paper we tried to investigate peer effects in Austrian schools using PISA 2000 data. Estimating peer effects is difficult mainly due to self-selection of students into schools and peer groups. As the Austrian school system is selecting students into different school types at the ages of 10 and 14, we introduced school type fixed effects in order to filter out the school type constant error term. The estimations show that the school type is an important determinant of academic outcome.

We found considerable positive peer effects in reading achievement. In mathematics and science, positive but smaller peer effects were found in some specifications. Thus, social interactions at school appear to be more important for reading proficiency than for maths and science. The estimations also give some indication for asymmetry of peer effects with respect to the students' own family background, meaning that students out of less favorable home environments are more reliant on their peers. Moreover, peer effects turned out to be asymmetric in favor of low ability students, meaning that the returns to a high quality peer group are higher for these students. Furthermore, social heterogeneity within the peer group appears to have some negative effects on student outcomes, in particular at the highest percentiles.

Peer effects are of political interest because they can serve as an argument for reallocating students into different schools or environments; the argument is that weak students would profit if they would be in the same class with high-performing kids. In order to be efficiency-enhancing – in the sense of increasing cognitive development of students – two conditions have to be met. First, peer effects should be higher for low-skilled students and second, higher heterogeneity in schools should have no detrimental effects on average learning in the group. A potential experiment would run as follows: Take the lowest-performing student from a low-performing class and transfer him or her to a high-performing class. This would have a positive peer group effect on the low-performing class because the least productive kid is removed, and will have a negative effect on the high-performing class because it reduces average achievement. This experiment would enhance average productivity as long as the loss for the high performers is smaller than the gain for the low performers. Moreover, the additional heterogeneity in the class should not be disruptive in a sense to decrease average cognitive development.

Our results are mildly in favor of reallocating students: peer effects are higher for the low-performing and heterogeneity has some, but only a small, negative effect. Some qualifications of our study have to be taken into account before drawing strong conclusions. We observe students only at the grade level, but not on the class level, which might underestimate the true peer effects. On the other hand, self-selection might not be fully addressed, which might lead to the opposite bias.

Moreover, the Austrian school system is highly stratified in school types. Cognitive outcomes – as measured in the PISA scores – differ enormously between school types. Secondary schools, aimed at preparing students primarily for a college education, show considerably higher average PISA scores. Whereas the public discussion centers around the question, whether the different school types should be abolished and all kids between 10 and 14 should be taught together in one type of school, our experiment with peer group effects relies only on variations within school types. Assessing the abolishment of early stratification in Austrian schools, therefore, would be an extrapolation of our results.

Other arguments for more ability-specific integrated schools come from growth studies. Krueger and Kumar (2002) have argued that the European emphasis on early tracking in schools in favor of vocational education might have harmed European growth prospects, because more general education is more conducive to the development of and adaptation to technological change.

6 Tables

Table 1: Summary Statistics – Reading Sample

Variable	Description	Mean	Std Dev[16]
Dependent Variables			
Reading score	Weighted likelihood estimate of reading test score[17]	522.657	85.131
Maths/science score	Weighted likelihood estimate of maths test score, science test score or the mean of both (maths/science sample)[18]	528.517	86.059
Individual Characteristics			
Female	Student is female	0.558	
Grade	Grade at school	9.452	
Family structure			
Nuclear family	Student lives with a mother and a father (or guardians)	0.865	
Single parent family	Student lives with a mother or a father (or one guardian)	0.119	
Other family	Students lives in other combinations including grandparents, siblings and other people	0.016	
Number of siblings	Number of siblings	1.527	1.125
Ethnicity			
Ethnic Austrian	Student is ethnic Austrian	0.855	
Immigrant	Student was not born in Austria	0.054	
Parents immigrated	Student's mother, father or both not born in Austria	0.091	
Family Background			
Mother education			
Mother no sec education	Mother did not attend school or finished elementary school only	0.039	
Mother low sec education	Mother finished lower secondary education (5^{th} - 8^{th} grade)	0.214	
Mother up sec education	Mother finished upper secondary education aimed at entering the labor market ('Polytechnische Schule', 'Berufsschule', 'BMS')	0.473	
Mother 'Matura'	Mother finished upper secondary education aimed at entering post-secondary or tertiary education	0.076	
Mother tertiary education	Mother finished post-secondary or tertiary education	0.198	
Socioeconomic status	Highest international socioeconomic index of occupational status reached by a parent, low values indicate a lower status	50.750	13.989
Cultural communication	Weighted likelihood estimate of cultural communication with parents (derived from the frequency of which parents engage in talking about political or social issues, films or tv programs and listening classical music with their child), low values indicate a lower frequency	-0.095	0.949
Books at home	Number of books at home	211.900	225.015
Educational resources	Weighted likelihood estimate of home educational resources (derived from the availability of a dictionary, a quiet place to study, textbooks and calculators), low values indicate poorer resources	0.307	0.760
Parent jobless	Student's father is looking for a job (if father is missing, student's mother is drawn on)	0.013	
Parents work fulltime	Both parents work fulltime or one parent works fulltime if the other is missing	0.344	

[16] No standard deviation is reported for dummy variables.
[17] The mean of the standard errors of the weighted likelihood estimates is 31.589 in reading and 44.214 in maths/science.
[18] All weighted likelihood estimates are standardized over all OECD countries, except the Netherlands; student scores to a mean of 500 and a standard deviation of 100 and background indices to a mean of 0 and a standard deviation of 1.

table 1 continued . . . .

Variable	Description	Mean	Std Dev
School Characteristics			
School size	Total enrollment in school	569.840	487.920
Total hours	Total number of full hours at school per year	1156.38	95.379
Urban school	School is located in a city with more than 100,000 residents	0.291	
Students/teacher	School size divided by the total number of teachers	9.718	2.285
Teacher qualification	Fraction of teachers who has an ISCED5A qualification in pedagogy (university degree)	0.905	0.186
Regular testing	Students are assessed by standardized and/or teacher-developed tests 4 or more times a year	0.861	
Promotion of gifted	School provides extra courses on academic subjects for gifted students	0.421	
Promotion of low achievers	School provides special training in language and/or special courses in study skills for low achievers	0.759	
Lack of material	There is (to some extent) lack of instructional material at school	0.117	
Teacher shortage	There is (a little or somewhat) shortage or inadequacy of teachers at school	0.238	
Teacher behavior	Weighted likelihood estimate of principal's view on teacher-related factors affecting school climate (teachers' expectations, student-teacher relations, meeting of students' needs, teacher absenteeism, staff is resisting change, too strict teachers and encouragement of students to achieve their full potential), low values indicate a poorer climate	-0.160	0.791
Peer Characteristics			
Socioeconomic status peers	Mean of socioeconomic status in the peer group	50.750	6.956
Status heterogeneity	Standard deviation of socioeconomic status in the peer group	12.277	2.764
Cultural communication peers	Mean of cultural communication in the peer group	-0.095	0.362
Communication heterogeneity	Standard deviation of cultural communication in the peer group	0.892	0.180
School Types			
Higher general schools			
GYM	'Gymnasium'	0.101	
RGYM	'Realgymnasium'	0.071	
ORG	'Oberstufenrealgymnasium'	0.071	
soAS	'Sonstige Allgemeinbildende Schule mit Statut'	0.010	
Higher vocational schools			
ALE	'Anstalt der Lehrer- und Erzieherbildung'	0.030	
BHSt	'Berufsbildende Höhere Schule (technisch, gewerblich)'	0.147	
BHSk	'Berufsbildende Höhere Schule (kaufmännisch)'	0.136	
BHSw	'Berufsbildende Höhere Schule (wirtschafts-, sozialberufl.)'	0.085	
BHSl	'Berufsbildende Höhere Schule (land-, forstwirtschaftlich)'	0.025	
Intermediate vocational schools			
BMSt	'Berufsbildende Mittlere Schule (technisch, gewerblich)'	0.039	
BMSk	'Berufsbildende Mittlere Schule (kaufmännisch)'	0.055	
BMSw	'Berufsbildende Mittlere Schule (wirtschafts-, sozialberufl.)'	0.066	
BMSl	'Berufsbildende Mittlere Schulen (land-, forstwirtschaftlich)'	0.042	
Pre-vocational school			
POLY	'Polytechnische Schule'	0.123	

Table 2: Estimates of Mean Peer Effects

Variable	(1) Reading score	(2) Reading score	(3) M/S score	(4) M/S score
Socioeconomic status peers	0.738		0.532	
	(0.362)**		(0.461)	
Cultural communication peers		23.802		14.690
		(5.110)***		(6.205)**
Female	12.669	10.509	-24.861	-25.749
	(3.018)***	(3.102)***	(3.017)***	(3.010)***
Grade	26.706	24.318	27.315	25.925
	(2.510)***	(2.676)***	(3.008)***	(3.020)***
Nuclear family	reference category			
Single parent family	7.789	7.734	8.814	9.132
	(4.669)*	(4.670)*	(4.625)*	(4.628)*
Other family	2.790	2.481	-4.214	-4.148
	(11.166)	(10.770)	(10.491)	(10.490)
Number of siblings	7.788	8.055	6.384	6.450
	(2.485)***	(2.487)***	(2.905)**	(2.908)**
Number of siblings squared	-1.473	-1.533	-1.439	-1.463
	(0.520)***	(0.521)***	(0.543)***	(0.547)***
Ethnic Austrian	reference category			
Immigrant	-28.340	-28.454	-32.528	-32.838
	(6.551)***	(6.585)***	(7.891)***	(8.029)***
Parents immigrated	-22.055	-22.524	-24.678	-25.089
	(5.640)***	(5.664)***	(6.143)***	(6.209)***
Mother tertiary education	reference category			
Mother 'Matura'	1.597	0.794	-3.365	-3.743
	(5.228)	(5.148)	(6.353)	(6.314)
Mother up sec education	1.474	1.263	1.430	1.205
	(3.783)	(3.760)	(4.209)	(4.210)
Mother low sec education	-2.149	-2.926	1.590	0.937
	(3.676)	(3.608)	(5.057)	(4.992)
Mother no sec education	-10.002	-9.600	-4.432	-4.361
	(7.615)	(7.468)	(8.844)	(8.826)
Socioeconomic status	0.236	0.241	0.076	0.075
	(0.107)**	(0.1073)***	(0.122)	(0.123)
Cultural communication	7.889	7.995	3.662	3.869
	(1.401)***	(1.404)***	(1.499)**	(1.500)**
Books at home	0.025	0.025	0.029	0.029
	(0.006)***	(0.006)***	(0.007)***	(0.007)***
Educational resources	1.532	1.543	2.879	2.889
	(1.794)	(1.797)	(2.035)	(2.045)
Parent jobless	-35.627	-38.105	-21.069	-22.311
	(10.887)***	(10.875)***	(10.318)**	(10.640)**
Parents work fulltime	-7.008	-7.210	-3.057	-3.477
	(2.554)***	(2.521)***	(3.122)	(3.094)
School size	0.013	0.012	0.012	0.011
	(0.005)***	(0.005)***	(0.006)**	(0.006)*
Total hours	-0.003	-0.011	0.033	0.030
	(0.023)	(0.023)	(0.029)	(0.029)
Urban school	-1.956	-3.861	-5.781	-6.856
	(4.804)	(4.582)	(5.042)	(4.914)

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table 2 continued . . . .

Students/teacher	-3.063	-2.269	-4.178	-3.479
	(3.699)	(3.286)	(4.079)	(3.756)
Students/teacher squared	0.026	-0.003	0.147	0.120
	(0.144)	(0.127)	(0.158)	(0.145)
Teacher qualification	10.330	12.472	11.641	12.138
	(10.172)	(9.314)	(10.929)	(10.764)
Regular testing	-7.693	-9.415	-4.359	-5.600
	(6.425)	(6.665)	(7.353)	(7.647)
Promotion of gifted	-0.094	-1.889	2.225	1.094
	(3.666)	(3.634)	(4.387)	(4.485)
Promotion of low achievers	-0.925	-0.299	4.441	4.974
	(4.336)	(4.182)	(4.999)	(5.161)
Lack of material	1.141	1.225	0.068	-0.202
	(4.649)	(4.529)	(5.658)	(5.591)
Teacher shortage	4.986	4.402	10.361	10.479
	(4.893)	(4.533)	(6.068)*	(5.731)*
Teacher behavior	7.952	6.844	5.245	4.348
	(2.714)***	(2.484)***	(2.775)*	(2.592)*
GYM	reference category			
RGYM	-19.437	-20.270	-14.590	-16.145
	(8.849)**	(8.756)**	(11.585)	(11.131)
ORG	-24.828	-28.981	-21.011	-23.936
	(10.844)**	(11.068)***	(13.135)	(13.239)*
soAS	-49.701	-46.575	-46.771	-45.444
	(11.812)***	(9.740)***	(10.995)***	(10.865)***
ALE	-14.276	-13.815	-19.696	-20.978
	(10.270)	(9.785)	(11.484)*	(10.812)*
BHSt	-31.791	-28.701	-17.317	-15.782
	(8.625)***	(8.937)***	(8.993)*	(9.405)*
BHSk	-7.013	-8.748	-9.314	-11.392
	(8.640)	(8.033)	(8.790)	(8.867)
BHSw	-32.382	-32.734	-32.345	-34.328
	(10.269)***	(9.799)***	(10.136)***	(9.281)***
BHSl	-15.412	-22.374	4.873	0.035
	(14.021)	(13.884)	(17.541)	(16.819)
BMSt	-73.040	-69.464	-67.474	-67.104
	(13.599)***	(12.283)***	(19.574)***	(18.317)***
BMSk	-45.653	-48.226	-54.972	-57.663
	(13.314)***	(11.461)***	(13.045)***	(9.548)***
BMSw	-60.784	-62.192	-64.720	-67.410
	(13.150)***	(11.438)***	(11.462)***	(10.259)***
BMSl	-84.291	-85.255	-69.304	-71.100
	(16.344)***	(13.899)***	(18.730)***	(16.381)***
POLY	-93.755	-92.245	-80.505	-81.452
	(9.923)***	(8.618)***	(11.309)***	(9.704)***
Constant	265.646	334.420	248.225	293.684
	(50.215)***	(44.230)***	(56.143)***	(48.076)***
Number of observations	3251	3251	2825	2825
Goodness of fit				

NOTES: Survey interval regression, standard errors in parentheses, dummies for missing variables included, ***, ** and * indicate a statistical significance at 1%, 5% and 10%,

Table 3: Estimates of Asymmetric Peer Effects with Respect to Family Background (A)

Variable	(1) Reading score	(2) Reading score	(3) M/S score	(4) M/S score
Socioeconomic status peers	1.553		1.535	
	(0.813)*		(0.949)	
Own se status * se status peers	-0.016		-0.020	
	(0.012)		(0.013)	
Cultural communication peers		23.443		13.816
		(5.162)***		(6.284)**
Own cult. com. * cult. com. peers		-5.558		-4.189
		(2.953)*		(4.150)
Number of observations	3251	3251	2825	2825

NOTES: Survey interval regression, standard errors in parentheses, dummies for missing variables included, individual characteristics, family background, school characteristics and school types included, ***, ** and * indicate a statistical significance at 1%, 5% and 10%,

Table 4: Estimates of Asymmetric Peer Effects with Respect to Family Background (B)

Variable		Reading	Maths/Science
Socioeconomic status	Top	0.715	0.562
		(0.366)*	(0.460)
	Middle	0.723	0.511
		(0.369)*	(0.469)
	Bottom	0.765	0.532
		(0.365)**	(0.462)
Cultural communication	Top	24.546	10.859
		(6.719)***	(9.851)
	Middle	15.621	11.201
		(7.723)**	(8.289)
	Bottom	31.438	20.399
		(6.316)***	(8.153)**
Number of observations		3251	2825

NOTES: Survey interval regression, standard errors in parentheses, dummies for missing variables included, individual characteristics, family background, school characteristics and school types included, ***, ** and * indicate a statistical significance at 1%, 5% and 10%,

Table 5: Estimates of Asymmetric Peer Effects with Respect to PISA Result Quantile Regressions

		Quantile				
		0.15	**0.25**	**0.50**	**0.75**	**0.85**
Reading	Socioeconomic status peers **(1)**	1.601	1.595	0.350	-0.147	-0.242
(3251 obs)		(0.588)***	(0.487)***	(0.419)	(0.383)	(0.496)
	Cultural communication peers **(2)**	25.249	29.613	22.523	28.130	31.902
		(9.190)***	(6.642)***	(6.154)***	(7.213)***	(8.276)***
Maths/Science	Socioeconomic status peers **(3)**	1.419	0.408	0.283	0.198	0.007
(2825 obs)		(0.668)**	(0.528)	(0.437)	(0.486)	(0.551)
	Cultural communication peers **(4)**	18.170	11.635	21.169	10.026	3.904
		(10.774)*	(9.090)	(6.575)***	(8.903)	(10.265)

NOTES: Quantile regressions, bootstrap standard errors in parantheses, dummies for missing variables included, individual characteristics, family background, school characteristics and school types included,
***, ** and * indicate a statistical significance at 1%, 5% and 10%,

Table 6: Estimates of Asymmetric Peer Effects and Heterogeneity Quantile Regressions

		Quantile				
		0.15	**0.25**	**0.50**	**0.75**	**0.85**
Reading	Socioeconomic status peers **(1)**	1.564	1.692	0.350	-0.151	-0.232
(3251 obs)		(0.490)***	(0.445)***	(0.422)	(0.390)	(0.546)
	Status heterogeneity	-1.129	-0.695	-0.151	0.031	-0.295
		(0.937)	(0.719)	(0.663)	(0.779)	(0.834)
	Cultural communication peers **(2)**	25.099	28.629	20.011	25.659	30.093
		(8.878)***	(6.697)***	(5.949)***	(6.592)***	(8.115)***
	Communication heterogeneity	2.230	-6.775	-19.390	-7.928	-8.569
		(12.914)	(9.985)	(9.309)**	(9.443)	(12.981)
Maths/Science	Socioeconomic status peers **(3)**	0.868	0.299	0.309	0.135	0.052
(2825 obs)		(0.618)	(0.509)	(0.420)	(0.522)	(0.571)
	Status heterogeneity	2.001	0.282	0.200	0.321	-0.840
		(1.122)*	(0.853)	(0.690)	(0.859)	(0.900)
	Cultural communication peers **(4)**	18.637	10.292	19.398	8.864	0.526
		(10.524)*	(9.830)	(6.661)***	(7.905)	(9.880)
	Communication heterogeneity	-2.234	-6.535	-7.544	-4.290	-22.286
		(15.139)	(12.234)	(10.924)	(10.242)	(10.565)**

NOTES: Quantile regressions, bootstrap standard errors in parantheses, dummies for missing variables included, individual characteristics, family background, school characteristics and school types included,
***, ** and * indicate a statistical significance at 1%, 5% and 10%,

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