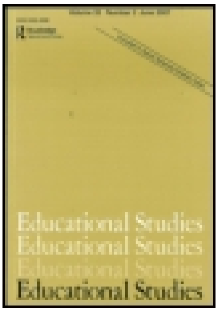

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Role of peers in student academic achievement in exogenously formed university groups

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Role of peers in student academic achievement in exogenously formed university groups

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We estimate the influence of classmates' ability characteristics on student achievement in exogenously formed university student groups. The study uses administrative data on undergraduate students at a large selective university in Russia. The presence of high-ability classmates has a significant positive effect on individual grades in key economics and mathematics courses as well as on overall academic performance. While a simple linear-in-means model reveals moderate peer effects, non-linear specifications give strong evidence that students at the top of the ability distribution derive the greatest benefit from high-ability classmates. Less able students are not affected by peers and have no significant influence on peers' outcomes.

Keywords: higher education; peer effects; student achievement

1. Introduction

The literature on peer effects in education studies the impact of classmates or schoolmates on educational outcomes for an individual student. James Coleman's "Equality of Educational Opportunity" report (Coleman et al. 1966) drew attention to this effect discussing an impact of racial segregation at US schools. While at that moment discussions were focused on political issues of key directions of educational policy, now peer effects are usually studied in the context of new approaches to the organisation of the educational process.

Most peer effect studies in post-secondary education consider roommates or groups in military academies because the educational curriculum usually allows students to choose most of the courses. The course selection can lead to self-selection. In the Russian university system, most courses during first two years of study are compulsory, and the students are administratively appointed to particular study groups that are the same for each course of their curriculum. This excludes the problem of selection endogeneity emerging when students choose courses guided by their classmates and/or by easiness of these courses.

We find empirical evidence of significant peer effects in student groups formed exogenously by university administration. The grades in particular disciplines and first-year overall performance for individual students improve with the growth of classmates' abilities. This effect has a non-linear character: the higher the share of

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high-ability students in the group and the greater the mean peer group ability, the better the achievement of a student who belongs as well to the most able. An increase in the percentage of less able students influences their classmates' achievement insignificantly.

2. Peer effects in university learning environment: recent findings in empirical literature

A number of recent studies demonstrate that the effectiveness of learning increases significantly when schools actively use elements of mutual education in student groups. In these schools, educational activities with interaction between students, such as collective/team work on learning tasks and project-based learning, become more and more prevalent, and the issue of student body composition acquires a new significance.

Many students and their parents, professors and university administrators take it for granted that a student's classmates affect his achievement and behaviour. However, empirical assessments of peer effects in higher education demonstrate contradictory evidence (see, e.g. the reviews of Sacerdote (2010); Epple and Romano (2010)).

The earliest empirical studies of peer effects in universities are based upon data analysis of university roommates. Sacerdote (2001) revealed non-linear peer effects: average grades were higher for those students whose roommate was in the top 25% of the class. Good students favourably influenced the achievement of relatively less able students, while there was no such influence for students in the middle of distribution. In Zimmerman (2003), peer effects turned out to be caused by the students' grades on the verbal portion of the SAT, and non-linear effects appeared here also: students in the middle of the SAT score distribution got worse grades if their roommates were students with low grades. In Brunello, De Paola, and Scoppa (2010), positive and significant effects were found for students specialising in engineering and mathematics; for humanities and social sciences, the effects turned out to be insignificant.

Another strand of research focuses on peer effects in student groups. Some of the studies test peer effects in very specific educational environments with intensive student interaction within group. Lyle (2007) found a **slight positive relation** between the current achievement of first-year students and the average current achievement of the group in the US Military Academy. It was also revealed that the increased dispersion of math SAT scores in a group improved student achievement, and that the given effect was achieved due to the presence of more talented students (Lyle 2009). Carrell, Fullerton, and West (2009) revealed significant peer effects for graduates of the US Air Force Academy, especially in mathematics and scientific disciplines. Again, non-linear effects were found: students with low verbal SAT grades mostly benefited from their communication with students with high SAT results. De Paola and Scoppa (2010) found statistically significant peer effects for the University of Calabria in Italy. In the work of Arcidiacono et al. (2011), moderate but statistically significant peer effects were found, mostly for the social sciences and less for physics and mathematics. In some studies, no significant peer effects were found (Arcidiacono and Nicolson 2005; Foster 2006; Parker et al. 2010).

3. Methodology of empirical study

The tendency of people belonging to one group to behave alike is usually explained by three effects (Manski 1993), that may be incorporated in the following model of individual achievement:

$$Y_i = \alpha + \beta X_i + \gamma X_{-i}^{peer} + \phi Y_{-i}^{peer} + \theta Z_{-ii} + \varepsilon_i \tag{1}$$

where Y_i is the index of the achievement of student i, X_i is the vector of individual characteristics of i, X_{-i}^{peer} is the vector of exogenous characteristics of the students studying with i (exogenous effects), Y_{-i}^{peer} is the index of achievement of the students studying with i (endogenous effects), Z_{-ii} is shared characteristics of the student and his classmates (correlated effects) and ε_i are random disturbances.

The indicators of achievement are usually students' average grades during various years (most often during the first year) or grades in particular disciplines or groups of disciplines. The characteristics of a student and his classmates primarily include the level of ability. The abilities themselves are hard to measure, therefore various proxy variables are used such as the results of standardised tests.

The estimation of model (1) involves some difficulties (Manski 1993; Epple and Romano 2010). The problem of simultaneity (reflection) is caused by the fact that not only does the achievement of a student's peers influences his academic grades, but his individual behaviour affects his classmates as well. For this reason, the estimates of coefficients are biassed. Characteristics that are common for a student and his environment often cannot be supervised, and this impedes the estimation of the corresponding coefficient. Therefore, the following reduced form is commonly estimated in practice:

$$Y_i = \alpha + \beta X_i + \gamma X_{-i}^{peer} + \varepsilon_i \tag{2}$$

Consequently, it becomes possible to evaluate the overall peer effect without differentiating between endogenous and exogenous effects.

If exogenous characteristics of classmates are their means, $X_{-i}^{peer} = \overline{X}_{-i}$, then model (2) is called linear-in-means. Such approach has its shortcomings (see, e.g. Hoxby (2000); Hoxby and Weingarth (2006)). With the linear-in-means model, it is impossible to estimate non-linear, asymmetric models of peer effects that are found empirically. For example, in the study of peer effects among college roommates, Sacerdote (2001) found that the least able students in the sample benefited the most from their proximity to high-ability peers. Asymmetric peer effects are significant from the point of view of educational policy. If the benefit from interaction with high-ability classmates is greater for able students than for low-ability students, then grouping students with similar abilities would increase overall performance.

4. Research context and data description

The empirical basis of our paper consists of data on students who entered the economics department at the National Research University – Higher School of Economics (HSE) in 2009. As of that year, the Unified State Examination (USE) became obligatory for all high school graduates, and we use this score as an ability measure.

To obtain a general certificate of secondary education, a high school graduate is obliged to successfully pass the USE test in two disciplines: the Russian language and mathematics. Exams in other disciplines are taken voluntarily. Throughout Russia, the USE consists of standardised tasks and a unified grading scale. Therefore, the results of the exam can be considered a unified assessment of the quality of schooling.

The principal application of the USE is that its results are acknowledged by universities as the results of entrance examinations in the corresponding general disciplines. For each field of study, the Ministry of Education and Science defines the list of three or four entrance examinations to the universities that have state accreditation. The USE scores in Russian and profile disciplines are compulsory for the entrance for all fields of study.

The winners of some Olympiads have the right to priority enrolment in public universities for tuition-free places. The list of such Olympiads is approved by the Ministry of Education and Science. An Olympiad is a form of creative contest in a selected field of study. The most prestigious one is the All-Russian School Olympiad, which has the largest number of participants from all over the country. Many leading universities organise their own Olympiads, whose results have to be accepted by other universities in their admission decisions. The selection of applicants without these privileges for the remaining tuition-free places is made according to the students' USE scores. The other enrolled students are charged tuition fees.

To enter the economics department of HSE based on the results of entrance examinations, it is obligatory to present USE results in four disciplines: mathematics, social studies, Russian language and foreign language. The winners of some Olympiads who had the right of prior enrolment presented their results only on the Russian language and mathematics examinations.

One of the most important elements of the study of peer effects is the correct identification of students who interact while learning. In our study, a student group was chosen as the environment influencing student achievement. HSE students spend a significant amount of study time during their classes in groups of up to 30 members. Lectures are usually delivered to several groups simultaneously, while seminar classes are delivered to each group separately. The university administration forms these groups. Compulsory courses constitute the majority of the educational curriculum in the first two years, and they are attended by all students. Thus, it can be considered that the peer group is formed exogenously. That allows us to avoid bias in peer effect estimation due to endogenous group formation.

The grades in several disciplines and the sum of grades for the first and the second years of study are used as the achievement measures in this work. The total score of each HSE student characterises his general academic performance. It is formed as the sum of grades in single disciplines with weight coefficients equal to the credit quantities of the educational load in a given discipline. HSE uses a ten-point grading scale. Grades lower than four are fail grades. The maximum total score for one year is 600 (grades of 10 in all disciplines multiplied by the annual workload of 60 credits). The current total score of HSE students is updated once mid-year.

Individual abilities were measured by a student's USE scores in Russian language and mathematics and by an indicator variable of whether the student had enrolled with Olympiad results from the All-Russian School Olympiad or the

Table 1. Descriptive statistics.

Variables	Obs	Mean	Std. dev.	Min	Max
USE score in Russian	318	77.1	10.3	45	100
USE score in Math	318	72.5	10.6	26	100
Winner of All-Russian Olympiad	318	0.13	0.34	0	1
Winner of Interregional Olympiad	318	0.14	0.35	0	1
Total score in the first year	257	377.7	95.5	119.5	580.5
Peer group mean USE score in mathematics (first year)	318	72.5	3.7	63.1	78.7
Share of peers in group with low USE score in mathematics (first year)	318	0.28	0.14	0.07	0.69
Share of peers in group with high USE score in mathematics (first year)	318	0.21	0.09	0.03	0.33
Grade in microeconomics	260	5.6	1.7	1	10
Grade in macroeconomics	253	6	1.8	1	10
Grade in economics of the firm	255	5.9	1.8	1	10
Grade in calculus	298	5.8	2.4	1	10
Grade in linear algebra	302	5.9	2.3	1	10
Grade in differential equations	251	6.8	2.3	1	10

Interregional Olympiad. The All-Russian School Olympiad is organised by the Ministry of Education and Science, while the Interregional Olympiad is carried out by HSE in cooperation with other universities.

The peer group was characterised by the average USE scores of a student's classmates in Russian language and mathematics, as well as the percentage of students in the group with low and high grades in mathematics.

Descriptive statistics of the variables used in the research are given in Table 1.

5. The results of peer effects estimation

For more detailed analysis of classroom peer effect, the sample of students was divided by ability into three subgroups (we used methodology applied to the estimation of non-linear peer effects as in Carrell, Fullerton, and West (2009) and Carrel, Sacerdote, and West (2012)). The bottom, middle and top subgroups were based on the distribution of predicted total score in the first year using a student's own ability characteristics: the USE scores in mathematics and Russian language and the indicator of winners of the All-Russian School Olympiad or the Interregional HSE Olympiad. One-third consisted of the students with the highest predicted total scores (the top of the distribution), one-third consisted of the students with the lowest predicted total scores (the bottom of the distribution) and the remaining third consisted of the "middle" students (the middle of the distribution). Peer coefficients were estimated both for the entire sample and for the top/middle/bottom thirds of the distribution.

The regression results are shown in Table 2. All of the explaining variables are significant at the level of 1%. The "premium" for those who were admitted through the Olympiad is quite large: winners of the All-Russian Olympiad receive 100 extra points (out of the maximum of 600) and winners of the Interregional Olympiad receive 62 extra points.

Table 2. The prediction of total scores of the students after the first year.

	Total score in the first year
USE score in mathematics	2.989** (0.694)
USE score in Russian language	2.451** (0.474)
Winner of the Interregional Olympiad	67.902** (12.306)
Winner of All-Russian Olympiad	91.503** (10.854)
Constant	−66.061 (51.356)
R^2	0.449
Observations	257

Notes: Robust standard errors are reported in parentheses. The symbols ** indicate that coefficients are statistically significant at the 1% level.

The predicted total scores for the first year were built upon the results of regressions. The entire sample of students was divided into three subgroups.

We consider two specifications of an empirical model of peer effects. In Model 1, the peer variables are mean scores on the USE in mathematics and Russian language of a student's classmates. The corresponding coefficient shows how much (on average) the student's grade changes when the peer group mean USE score increases by one. In Model 2, the shares of peers in the group who have relatively high and low USE scores in mathematics were used as explaining variables. We defined USE scores as low if they were in the bottom quartile of the year-cohort USE distribution. Respectively, high USE scores were in the top 25%. The student's own USE scores in mathematics and Russian language and the dummy variables for Olympiad winners were included as control variables in all regressions.

Disciplines that are compulsory for all students are a significant part of the educational programme during the first two years (90% of total workload). Among these disciplines are key courses in macroeconomics, microeconomics, economics of the firm and key mathematics courses in calculus, linear algebra and differential equations.

Tables 3 and 4 show the estimates of models 1 and 2 for economics courses. In Tables 5 and 6, the estimation results are presented for mathematics courses. In all the regressions, the subject grades are positively influenced by peer USE scores in mathematics and the share of students with high USE scores in mathematics.

Simple linear-in-means regressions (odd-numbered in Tables 3 and 5) show significant peer effects only for microeconomics (number 1 in Table 3) and linear algebra (number 5 in Table 5).

Magnitude of peer effects may be evaluated by standardised coefficient. Standardised regression coefficient measures the expected standard deviation change in the dependent variable associated with a one standard deviation change in the independent variable. For microeconomics standardised coefficient is 0.12, i.e. a one standard deviation increase in the peer group USE math score associated with increase in grade by 12% of a standard deviation. Standardised coefficient for linear algebra is 0.10. Standardised coefficient at own USE math scores is 0.32 for microeconomics and 0.37 for linear algebra.

The mean effect is dissimilar for different thirds of the distribution. Classmates' mean USE math scores are statistically significant for the top third of the distribution for grades in three economic courses and one math course. The share of

Table 3. Estimates of peer group effects for grades in economics courses (model 1).

	Microeconomics		Macroeconomics		Economics of the firm	
	(1)	(2)	(3)	(4)	(5)	(6)
Peer group mean USE score in mathematics ×						
× All	0.062* (0.026)		0.031 (0.027)		0.054 (0.029)	
× Top		0.126** (0.036)		0.090* (0.043)		0.139* (0.057)
× Middle		0.042 (0.044)		0.027 (0.047)		0.014 (0.044)
× Bottom		0.023 (0.058)		−0.019 (0.051)		0.029 (0.047)
Control variables	Own USE in mathematics and the Russian language, winner of the Interregional Olympiad, winner of All-Russian Olympiad					
R^2	0.393	0.402	0.303	0.314	0.330	0.355
Observations	260	260	253	253	255	255

Notes: Robust standard errors are reported in parentheses. The symbols **, * indicate that coefficients are statistically significant at the 1 and 5% level, respectively.

Table 4. Estimates of peer group effects for grades in economics courses (model 2).

	Microeconomics		Macroeconomics		Economics of the firm	
	(1)	(2)	(3)	(4)	(5)	(6)
Share of peers with low USE scores in mathematics ×						
× All	−1.128 (0.981)		0.937 (1.019)		−0.072 (0.959)	
× Top		−0.127 (1.618)		1.778 (2.042)		1.478 (2.171)
× Middle		−0.942 (1.260)		−0.938 (1.264)		−0.326 (1.206)
× Bottom		−2.541 (1.970)		1.851 (1.854)		−2.092 (1.592)
Share of peers with high USE scores in mathematics ×						
× All	0.929 (1.368)		2.508 (1.437)		2.071 (1.418)	
× Top		4.372* (2.160)		5.215* (2.225)		7.282* (2.396)
× Middle		0.866 (1.850)		0.368 (2.284)		0.176 (2.013)
× Bottom		−3.640 (2.837)		1.325 (3.014)		−2.843 (2.618)
Control variables	Own USE in mathematics and the Russian language, winner of the Interregional Olympiad, winner of All-Russian Olympiad					
R^2	0.393	0.412	0.309	0.326	0.331	0.373
Observations	260	260	253	253	255	255

Notes: Robust standard errors are reported in parentheses. The symbol * indicate that coefficients are statistically significant at the 5% level.

Table 5. Estimates of peer group effects for grades in math courses (model 1).

	Calculus		Differential equations		Linear algebra	
	(1)	(2)	(3)	(4)	(5)	(6)
Peer group mean USE score in mathematics ×						
× All	0.037 (0.028)		0.009 (0.045)		0.066* (0.028)	
× Top		0.184** (0.056)		0.065 (0.076)		0.065 (0.054)
× Middle		−0.046 (0.045)		0.020 (0.066)		0.082 (0.050)
× Bottom		0.030 (0.043)		−0.068 (0.094)		0.070 (0.042)
Control variables	Own USE in mathematics and the Russian language, winner of the Interregional Olympiad, winner of All-Russian Olympiad					
R^2	0.466	0.490	0.169	0.180	0.426	0.435
Observations	298	298	251	251	302	302

Notes: Robust standard errors are reported in parentheses. The symbols **, * indicate that coefficients are statistically significant at the 1 and 5% level, respectively.

Table 6. Estimates of peer group effects for grades in math courses (model 2).

	Calculus		Differential equations		Linear algebra	
	(1)	(2)	(3)	(4)	(5)	(6)
Share of peers with low USE scores in mathematics ×						
× All	−0.066 (0.840)		0.791 (1.547)		−0.277 (0.890)	
× Top		1.269 (2.032)		1.671 (3.296)		2.326 (1.702)
× Middle		−0.979 (1.600)		−0.369 (2.388)		−2.047 (1.696)
× Bottom		−0.578 (1.025)		0.820 (2.465)		−0.638 (1.114)
Share of peers with high USE scores in mathematics ×						
× All	0.671 (1.396)		1.577 (1.804)		2.239 (1.371)	
× Top		7.296** (2.560)		4.280 (2.953)		4.887* (2.245)
× Middle		−3.776 (2.461)		1.044 (3.257)		0.623 (2.796)
× Bottom		−0.559 (1.946)		−2.251 (3.120)		1.706 (1.852)
Control variables	Own USE in mathematics and the Russian language, winner of the Interregional Olympiad, winner of All-Russian Olympiad					
R^2	0.464	0.493	0.172	0.185	0.426	0.439
Observations	298	298	251	251	302	302

Notes: Robust standard errors are reported in parentheses. The symbols **, *indicate that coefficients are statistically significant at the 1 and 5% level, respectively.

peers with high USE scores in mathematics is also significant for the top third students for three economic courses and for two math courses. Share of peers with low USE scores in mathematics is insignificant in all regressions.

The effect of classmates depends on the particular discipline, peculiarities of teaching methods, the proportion of lecture vs. seminar classes, types of homework assignments, etc. Thus, estimation of peer effects for the aggregated outcome measure is of great interest.

The total score of a student reflects general achievement in all disciplines, including electives. For each elective course, a particular group is formed. Therefore, it erodes the effect of influence from the students of the administratively formed group. However, the academic environment within the study groups can affect students even when they attend classes in individually chosen disciplines. A general attitude toward studies may serve as the channel of peer influence in this case (The importance of attitude toward studies as a peer effect mechanism is noted, for example, in Stinebrickner and Stinebrickner (2008); Parker et al. (2010)).

Table 7 shows the estimates for model 1 for total score in the first year. Mean effect is significant for the entire sample and for the top subgroup. A one standard deviation increase in the peer group USE math score improves student's first year total score by 11% of a standard deviation, while a one standard deviation increase in own USE math score increases overall performance by 27%. The estimates for model 2 are shown in Table 8. Share of peers with high USE scores in mathematics is positive, and close to be significant at 5% level (*t*-statistics equals 1.91).

The effect of peer USE math scores and of the share of students with high math USE scores in the group is positively and statistically significant at the 5% level for the first-year total score for the quartile of the most able students.

Summing up, we find evidence that students benefit from learning with their most able classmates. An increase in the percentage of students with low USE scores usually did not influence student achievement. This result is consistent with findings in other studies of peer group effects (Carrell, Fullerton, and West 2009; Lyle 2009; De Paola and Scoppa 2010).

Table 7. Estimates of peer group effects for total scores in the first year (model 1).

	Total score in the first year	
	(1)	(2)
Peer group mean USE score in mathematics ×		
× All	3.113* (1.274)	
× Top		4.857* (2.087)
× Middle		1.455 (2.087)
× Bottom		4.373 (2.567)
Control variables	Own USE score in mathematics and the Russian language, winner of the Interregional Olympiad, winner of All-Russian Olympiad	
R^2	0.461	0.482
Observations	257	257

Notes: Robust standard errors are reported in parentheses. The symbol * indicate that coefficients are statistically significant at the 5% level.

Table 8. Estimates of peer group effects for total scores in the first year (model 2).

	Total score in the 1st year	
	(1)	(2)
Share of peers with low USE scores in mathematics ×		
× All	−71.008 (44.594)	
× Top		23.666 (87.758)
× Middle		−103.652 (61.903)
× Bottom		−125.698 (79.125)
Share of peers with high USE scores in mathematics ×		
× All	4.335 (68.065)	
× Top		188.997 (98.696)
× Middle		−100.591 (104.997)
× Bottom		−64.648 (141.048)
Control variables	Own USE score in mathematics and the Russian language, winner of the Interregional Olympiad, winner of All-Russian Olympiad	
R^2	0.459	0.486
Observations	257	257

Note: Robust standard errors are reported in parentheses.

In our case, more detailed analysis shows that the positive effect from high-able peers is significant only when a student also belongs to high-ability group. This finding is in agreement with single-crossing model, according to which “students with a higher initial level of the outcome are more sensitive to their peers’ having a high level of the outcome” (Hoxby and Weingarth 2006). There are several possible explanations for this effect. One is that students of similar ability may form endogenous friendship networks inside exogenous student groups (evidence of homophily in friendship formation are reported, for example, in Marmaros and Sacerdote (2006); Mayer and Puller (2008); Carrell, Sacerdote, and West (2012)). So positive spillover from high-able peers mostly benefit their friends who are also belong to the upper part of ability distribution. Another explanation refers to the competition effect: while high-ability students compete with each other for higher grades and therefore induce extra effort, students from low-ability group may feel themselves just too far behind (in terms of current achievements) to consider their high-able classmates as a positive inspiring example (see Androushchak (2005) for detailed analysis). Finally, less able students may be less affected by their classmates due to the lower attendance rate within this group.

6. Summary

In the paper, we test the presence of peer effects in a student group, specifically the influence of the ability of other students on student achievement. The empirical base of the research is administrative data on students in the economics department of one of the leading Russian universities in the field of social sciences. Exogenous formation of student groups and the prevalence of compulsory disciplines in the programme in the first two years exclude the bias problem that might arise because of students selecting courses or classmates.

As a measure of student ability, we use the results of the national standardised tests in Russian language and mathematics that are taken by every secondary school graduate in Russia. The classroom peer effect is estimated with two different peer variables: classmates' average test scores in mathematics and Russian language, and the share of students in the top and bottom quartile of the mathematics test score distribution. For analysis of the non-linear nature of peer effects, the whole student cohort is divided into subgroups with relatively high-ability, low-ability and middle-ability students. Estimates for peer effect coefficients are calculated for each subsample.

We find empirical evidence of statistically significant peer effects in a student group, with a non-linear influence of other students on student outcomes: the higher the percentage of the most able students in a group and the greater the mean peer group ability, the better the achievement of a student from the top third of the ability distribution. An increase in the percentage of less able students does not have a statistically significant effect.

As for policy implications of the paper findings, it seems that ability tracking approach in group composition certainly favours academically strong students. However, any change in group composition policy may affect intergroup relations and interaction effects in a way that is difficult to foresee on the base of random assignment study.

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