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Fritz Schiltz, Deni Mazrekaj, Daniel Horn, Kristof De Witte

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# Does It Matter When Your Smartest Peers Leave Your Class? Evidence from Hungary.

Fritz Schiltz\*, Deni Mazrekaj, Daniel Horn and Kristof De Witte

## Abstract

Elite schools in Hungary cherry pick high achieving students from general primary schools. The geographical coverage of elite schools has remained unchanged since 1999, when the establishment of new elite schools stopped. We exploit this geographical variation and estimate the impact of high achieving peers leaving the class on student achievement, behaviour, and aspirations for higher education. Our estimates indicate moderate but heterogeneous effects on those left behind in general primary schools.

**JEL:** I21, I24, P36

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\*Schiltz: McKinsey & Company; Faculty of Economics and Business, KU Leuven, Naamsestraat 69, 3000 Leuven, Belgium (email: fritz.schiltz@kuleuven.be; +32 16 37 42 64); Mazrekaj: Faculty of Economics and Business, KU Leuven, Naamsestraat 69, 3000 Leuven, Belgium (email: deni.mazrekaj@kuleuven.be). Horn: Centre for Economic and Regional Studies, Hungarian Academy of Sciences, Tóth Kálmán str. 4. 1097 Budapest, Hungary (email: horn.daniel@krtk.mta.hu); De Witte: Faculty of Economics and Business, KU Leuven, Naamsestraat 69, 3000 Leuven, Belgium; UNU-MERIT, Boschstraat 24 6211 AX Maastricht, the Netherlands (email: kristof.dewitte@kuleuven.be, k.dewitte@maastrichtuniversity.nl). The authors are grateful to Eric Maurin, Scott Carrell, Eric Hanushek, Gabor Kezdi, Zoltan Hermann, Bas van der Klaauw and conference participants in Atlanta, Budapest, Tallinn, Leuven, Maastricht, Lyon, Berlin, and Antwerp for their helpful comments and suggestions. The authors received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 691676 (EdEN). The authors declare that they have no relevant or material financial interests that relate to the research described in this paper.

# 1 Introduction

Peer effects are believed to influence many social outcomes. Peers may play a role in a person's health (Cohen-Cole & Fletcher, 2008), empathy (Boisjoly et al., 2006), productivity (Falk & Ichino, 2006), entrepreneurship (Lerner & Malmendier, 2013) and the propensity to engage in criminal activities (Kling et al., 2005). However, the effect of peers on student achievement is more ambiguous. In a comprehensive review of the literature, Sacerdote (2014) finds that although about half the studies estimate modest to large peer effects on student achievement, another half of the studies do not find any evidence of peer effects at all.

In this paper, we use Hungarian data to estimate the effect of high ability peers leaving the class on achievement, behaviour, and aspirations of children who were left behind. Hungary provides a unique setting to study what happens when the highest achieving peers leave the class. In the 1990s, many elite schools emerged across Hungary as a response to the centralized system of education under communist rule. The establishment of these new elite schools stopped in 1999 and their geographical coverage has remained unchanged since then.

The highest achieving primary school students typically switch to an elite school after grade 6 (age 12), two years before the end of primary education. In this context, we first show that the distance to the nearest elite school is unrelated to pupils' academic ability as measured in grade 6. Nonetheless, we also show that the distance to the nearest elite school is a strong predictor of the probability that the highest achieving pupils leave their class and switch to an elite school after grade 6. Using the distance to the nearest elite schools as an instrumental variable, we find that the performance of stayers on grade 8 mathematics test scores is negatively impacted by the proportion of peers who switch to an elite school at the end of grade 6, two years before. Specifically, we find that a 5 percentage points increase in the share of leavers (one student in an average sized class) leads to a reduction in mathematics test scores of about 4% of a standard deviation for stayers.

Our paper contributes to the large and still growing literature on peer effects at school (see e.g. Angrist & Lang, 2004; Carrell et al., 2009). Our paper is also closely related to the literature on elite schools and tracking (Abdulkadiroglu et al., 2014; Clark et al., 2016; Pop-Eleches & Urquiola, 2013). To the best of our knowledge, our paper is one of the very first to evaluate the effect of elite schools on non-elite students, whereas earlier literature mainly focused on the effect of elite schools on elite students. Guyon et al. (2012) provide, however, an evaluation of the overall effect of the sudden extension of elite schools in Northern Ireland in the late 1980s, which encompasses the effect of these schools

on both non-elite and elite students.

The relevance of our results directly relates to the school choice debate. The effects of top students are at the centre of several policy interventions related to, among others, ability tracking versus detracking, school segregation versus school busing, and racial segregation versus affirmative action (Lin, 2010). In the US, for example, the emergence of charter schools could lead to comparable cherry picking and the subsequent impact for those left behind in public schools.

## 2 Background

In the Hungarian education system, compulsory education starts at the age of six and ends at the age of sixteen. Children enrol in primary education when they reach school maturity (at the age of six) and continue primary education for four, six, or eight years. Eight-year primary education was introduced under communist rule, and is the most widespread type of primary education in all Central and Eastern Europe. Since 1989, children can also switch to an elite school after finishing the fourth grade (age 10) or after finishing the sixth grade (age 12). The introduction of elite schools is also typical for most countries of Central and Eastern Europe, as a response to the centralized system of education, uniformly imposed under communism.<sup>1</sup> In the year of their introduction (1989), only two elite schools were opened. By 1999, 44 percent of the Hungarian regions included at least one elite school. This corresponds to 6.36 percent of all municipalities, as depicted in Figure 1. Historically, the most developed regions (e.g. cities) pushed more for the establishment of elite schools. As a result, the geographical coverage in 1999 strongly relied on socio-economic status, and was hence far from random. However, as we will show in Section 5.1 (Table 2), the distance to elite schools is independent of student test scores in grade 6, before students start leaving, conditional on controls.<sup>2</sup>

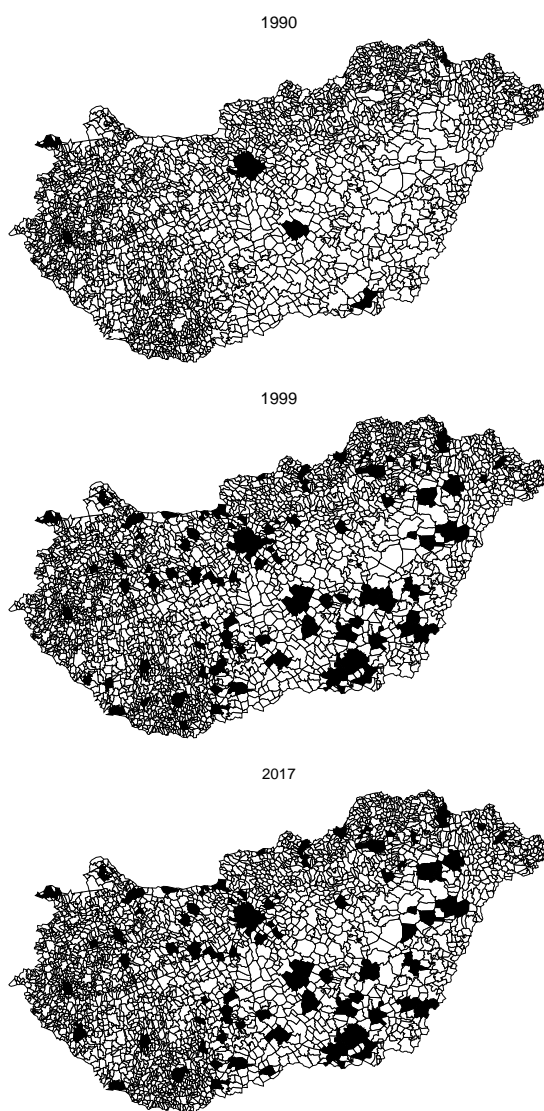
The aim of elite schools is to prepare students for university. They provide the exact same qualification (*érettségi*) as the academic secondary schools (*gimnázium*)<sup>3</sup>, although they are considered more prestigious - comparable to grammar schools in the UK or exam schools in the US. The central government halted elite school formation in 1999. The reason for this was the presumed negative effects on social cohesion. Nonetheless, although no new elite schools were formed after 1999, the elite schools already in place were allowed to continue

<sup>1</sup>A more comprehensive overview of the Hungarian education system and the introduction of elite schools is available on <https://cps.ceu.edu/publications/working-papers/educational-system-hungary>.

<sup>2</sup>In addition, the average distance to the closest elite schools remained virtually constant over time for the available cohorts, at around 16.3 kilometres.

<sup>3</sup>The two other tracks are a vocational track (*szakközépiskola*) and a trade track (*sza-kiskola*).

Figure 1: Adoption of elite schools in Hungary.



*Notes:* This figure displays elite school adoption over time in Hungary. Dark areas indicate Hungarian municipalities with at least one elite school. Since the introduction of the first elite school in 1989 in Budapest, their adoption has exploded between 1990 and 1999, when elite school establishment was halted. The geographical coverage of elite schools has remained unchanged since then. This is illustrated in the bottom panel using 2017 data.

their operations. Today, around 300 elite schools operate throughout Hungary, resulting in over 5,000 students leaving their classes every year to enrol in an elite school - around 6% of all primary education students.

Admission to elite schools (and to upper secondary schools, in general) proceeds as follows in Hungary. First, each student must rank any number of elite schools they wish to apply to (application is free). Second, each student who applied to at least one elite school must take a central entrance exam in mathematics and in Hungarian language. Each school can decide about the weight of this central exam in their own admission process, but its weight must be between 50% percent and 100%. The schools can also take previous grades and an institutionally organized (typically oral) entrance exam into account. Finally, each school must rank every student who applied to their institution, and then a central Gale-Shapley type algorithm allocates all students to one school (see <http://www.matching-in-practice.eu/secondary-schools-in-hungary/>). Naturally, students with more ‘exposure’ to elite schools are more likely to apply. This ‘exposure’ might be due to high-status parents, better abilities, or - as we argue - distance. Ultimately, the school principal decides on the admission of students.<sup>4</sup> Although most elite schools are public (75%) and do not charge tuition fees, elite schools that are privately organized, as foundation (4%) or church schools (20%) can charge tuition.<sup>5</sup>

In the Hungarian education system, classes are typically taught by the same teacher in the first four grades, for all subjects. Thereafter, from grade 5 to grade 8, teachers specialize in a certain subject and teach this specific course. However, the same group of teachers teaches the same students during this period. Once students have departed to an elite school, it is possible, but not frequent, that the school decides to reshuffle classes if there are too few students left in each class. Nonetheless, we formally test, and reject, whether our results are driven by class reshuffling.

<sup>4</sup>The autonomy of schools to select students inhibits us from using a regression discontinuity design due to missing data on admission criteria.

<sup>5</sup>The remaining 1% of elite school providers is categorized as ‘other’, and includes for-profit companies and ‘multi-purpose small area associations’. There are no official statistics about the fees charged by private elite schools in Hungary, if they do. Visiting the websites of a number of private elite schools, we can report that their monthly tuition fee is around 60-80 thousand Hungarian forints, which is around 200-300 euros.

### 3 Data and Descriptive Statistics

#### 3.1 Dataset Construction

Our dataset is constructed by integrating student, class, and school level information from the National Assessment of Basic Competencies (NABC) database, and the geographic location of students and schools from the Hungarian Academy of Sciences Geography (GEO) database. The NABC covers all students in compulsory education in Hungary.<sup>6</sup> It includes standardized test scores for mathematics and reading that follows the model of the OECD Programme for International Student Assessment (PISA). In addition, teacher-graded GPA scores are collected, as well as behavioural assessments done by the teacher for every student on a Likert scale from 1 to 5, where higher scores indicate better behaviour. Finally, students are asked whether they aspire to enrol in higher education (at the Bachelor or Master level) after completing compulsory education.<sup>7</sup>

Unlike PISA, which is conducted once every three years, the NABC is conducted annually. Each year, the NABC includes test scores of a cohort of students at the end of grade 6 (age 12) and just before graduation from primary school, in grade 8 (age 14). The timing of the first test corresponds to the final month of grade 6 (May) before students leave to elite schools. Considering these moments of data collection, we focus our analysis on the effect of students leaving for elite schools after grade 6. In subsequent analyses, therefore, we study two-year differences in test scores between grade 6 and grade 8. This study uses data from 2008 to the most recent records in 2015, encompassing the graduating cohorts in grade 8 of 2010 to 2017.

For each student in grade 6, we obtain a measure of the distance from their home to the nearest elite school. This data is retrieved from the GEO database and is available from 2008 to 2016. *Volan*, the official Hungarian bus company participated in the establishment of the database. Distance measures were calculated using the routes followed by buses of *Volan*, and indicate the exact distance by bus, in meters, from students' home addresses to the nearest elite school. In addition, alternative measures such as time in minutes by bus and time in minutes by car are available. We matched all distance measures to students in the NABC data. We take the mean distance to the closest elite school of each student's peers (excluding that student's distance) at the class level. Using student addresses in grade 6 and grade 8, we are also able to assess the

<sup>6</sup>Earlier studies using this dataset include Kertesi & Kezdi (2011) on the Roma/non-Roma test score gap.

<sup>7</sup>Given that GPA and behaviour (and higher education aspirations) were teacher- (student-) reported, the share of missing data is higher than for compulsory centralized tests. We observe GPA for 64 percent of the sample, behaviour for 74 percent, and aspirations for 77 percent. We therefore discuss the effects on these alternative outcome variables in Section 5.4, while focusing our main analysis on student test scores in Section 5.1.

mobility of students and households within this two-year period.

### 3.2 Descriptive Statistics

Summary statistics are displayed in Table 1. Our sample includes 536,846 students in primary education. We divide this sample into those who leave general education schools for elite schools after grade 6 (“Leavers”;  $N=38,240$ ) and those who are left behind (“Stayers”;  $N=498,606$ ). In the final column of Table 1, we display the group-level differences of all the variables.

Elite schools attract exceptionally high achieving students. Students leaving for elite schools score almost one standard deviation higher than the typical student left behind in general primary education on the standardized NABC mathematics and reading tests in grade 6.<sup>8</sup> ‘Elite students’ also obtain higher GPA scores on average, are perceived to behave better, and are more likely to aspire enrolling in higher studies.

Students who leave general primary education for elite schools are more likely to come from families with a higher socio-economic status - proxied by parental education, employment, and the number of books in the family. Also, boys are slightly more likely to enrol in elite schools (although boys comprise 52.5 percent of leavers, the corresponding share of girls among the stayers is 49.9 percent).

In grade 6, the average class size is relatively similar for leavers and stayers, at 23 and 24 students per class, respectively.<sup>9</sup> It naturally follows that the departure of high achieving students results in a decreased class size in grade 8 for those left behind, which may also affect test scores (Fredriksson et al., 2013; Krueger & Whitmore, 2001). In our dataset, however, the number of leavers per class is less than or equal to two in almost 83 percent of the classes, and less than or equal to three in 90 percent of the classes. Hence, this limited class size effect is unlikely to drive the results we present in this paper (see also Section 6).

The spatial mobility of students is very low in Hungary, as almost 93 percent of students do not move between grade 6 and grade 8. The percentage of students who moved and went to an elite school is only 0.4 percent. Two out of three movers in our dataset do not switch schools, which also suggests that spatial mobility motivated by school choice is very limited in Hungary. The average distance to the nearest elite school is less than half for leavers

<sup>8</sup>Table B1 in the Appendix disentangles this comparison for every reference group (class, school, settlement (ZIP-code), region, and cohort).

<sup>9</sup>However, in grade 8, classes in elite schools consisting of leavers are significantly and substantially larger (30 compared to 21). This can be explained by the fact that elite schools are commonly organized within secondary schools where classes are larger on average.

Table 1: Descriptive statistics

|                           |                                       | Stayers (N=498,606) |  | Leavers (N=38,240) |         | Diff     |
|---------------------------|---------------------------------------|---------------------|--|--------------------|---------|----------|
|                           |                                       | Mean                | SD                                     | Mean               | SD      |          |
| Outcome variables         |                                       |                     |  |                    |         |          |
| Test scores               |                                       |                     |  |                    |         |          |
| Mathematics grade 6       |                                       | 1490.320            | 185.507                                | 1646.725           | 174.262 | -156.405 |
| Mathematics grade 8       |                                       | 1604.049            | 198.106                                | 1747.011           | 176.631 | -142.962 |
| Reading grade 6           |                                       | 1480.045            | 193.773                                | 1644.262           | 166.401 | -164.217 |
| Reading grade 8           |                                       | 1554.320            | 197.706                                | 1709.823           | 162.976 | -155.503 |
| GPA                       |                                       |                     |  |                    |         |          |
| GPA grade 6               |                                       | 4.003               | 0.733                                  | 4.618              | 0.433   | -0.615   |
| GPA grade 8               |                                       | 3.935               | 0.776                                  | 4.230              | 0.569   | -0.294   |
| Behaviour                 |                                       |                     |  |                    |         |          |
| Score in grade 6          |                                       | 4.120               | 0.767                                  | 4.638              | 0.509   | -0.518   |
| Score in grade 8          |                                       | 4.085               | 0.808                                  | 4.426              | 0.615   | -0.341   |
| Aspirations               |                                       |                     |  |                    |         |          |
| Share in grade 6          |                                       | 0.513               | 0.499                                  | 0.913              | 0.281   | -0.399   |
| Share in grade 8          |                                       | 0.512               | 0.499                                  | 0.903              | 0.296   | -0.391   |
| Student characteristics   |                                       |                     |  |                    |         |          |
| Gender                    |                                       |                     |  |                    |         |          |
| Male                      |                                       | 0.499               | 0.500                                  | 0.525              | 0.500   | -0.027   |
| Education parents         |                                       |                     |  |                    |         |          |
| Father                    |                                       |                     |  |                    |         |          |
| Primary                   |                                       | 0.163               | 0.369                                  | 0.031              | 0.175   | 0.131    |
| Secondary                 |                                       | 0.544               | 0.498                                  | 0.413              | 0.492   | 0.131    |
| Higher                    |                                       | 0.150               | 0.357                                  | 0.415              | 0.493   | -0.265   |
| Mother                    |                                       |                     |  |                    |         |          |
| Primary                   |                                       | 0.200               | 0.400                                  | 0.034              | 0.180   | 0.167    |
| Secondary                 |                                       | 0.482               | 0.500                                  | 0.351              | 0.477   | 0.131    |
| Higher                    |                                       | 0.196               | 0.397                                  | 0.486              | 0.500   | -0.290   |
| Employment parents        |                                       |                     |  |                    |         |          |
| Father                    |                                       | 0.667               | 0.471                                  | 0.709              | 0.454   | -0.041   |
| Mother                    |                                       | 0.624               | 0.484                                  | 0.726              | 0.446   | -0.102   |
| Books at home             |                                       |                     |  |                    |         |          |
| <50                       |                                       | 0.273               | 0.446                                  | 0.066              | 0.248   | 0.207    |
| >50 & <300                |                                       | 0.358               | 0.479                                  | 0.285              | 0.451   | 0.073    |
| >300                      |                                       | 0.256               | 0.437                                  | 0.525              | 0.499   | -0.268   |
| Class size                |                                       |                     |  |                    |         |          |
| Grade 6                   |                                       | 23.116              | 5.446                                  | 24.109             | 4.878   | -0.993   |
| Grade 8                   |                                       | 21.281              | 5.518                                  | 30.107             | 5.251   | -8.826   |
| Spatial mobility          |                                       |                     |  |                    |         |          |
| Student moved (G6-G8)     |                                       | 0.073               | 0.080                                  | 0.087              | 0.086   | -0.014   |
| Distance (km)             |                                       | 16.954              | 16.082                                 | 7.030              | 9.802   | 9.923    |
| Mean class distance (km)  |                                       | 16.836              | 14.943                                 | 7.598              | 8.623   | 9.237    |
| School characteristics    |                                       |                     |  |                    |         |          |
|                           | Schools where no one left<br>(54.68%) |                     | Schools where someone left<br>(45.32%) |                    |         |          |
| Mathematics grade 6       |                                       | 1479.887            | 191.668                                | 1515.765           | 184.614 | -35.877  |
| Reading grade 6           |                                       | 1465.892            | 199.282                                | 1509.294           | 191.570 | -43.402  |
| GPA grade 6               |                                       | 3.983               | 0.758                                  | 4.090              | 0.709   | -0.107   |
| Behaviour grade 6         |                                       | 4.096               | 0.786                                  | 4.196              | 0.742   | -0.100   |
| Aspirations grade 6       |                                       | 0.471               | 0.499                                  | 0.590              | 0.492   | -0.119   |
| Father Higher Edu         |                                       | 0.122               | 0.327                                  | 0.200              | 0.400   | -0.078   |
| Mother Higher Edu         |                                       | 0.166               | 0.372                                  | 0.250              | 0.433   | -0.085   |
| >300 books                |                                       | 0.223               | 0.416                                  | 0.312              | 0.463   | -0.089   |
| Class size in grade 6     |                                       | 22.194              | 6.135                                  | 23.944             | 4.641   | -1.750   |
| Distance (km)             |                                       | 23.540              | 15.765                                 | 10.597             | 14.804  | 12.943   |
| Share of students leaving |                                       | 0                   | 0                                      | 0.100              | 0.131   | -0.100   |

*Notes:* All differences ('Diff') are significant at the 0.01 level. 'Stayers': students left behind in primary schools. 'Leavers': students leaving their classes and schools for an elite school. In all subsequent analyses, we standardize mathematics and reading test scores to a mean of zero and unit variance within grade and year. 'Schools where no one left' correspond to schools where in a given cohort no student left to an elite school. 'GPA' is the grade point average, graded by the teacher. 'Behaviour' is measured as a Likert scale (1-5), graded by the teacher, with higher scores indicating better behaviour. 'Aspirations' represents a dummy indicating students' response to the survey question asking whether he or she aims to enrol in higher education. The latter three outcome variables are presented for the subsample of students where data was observed, at 64%, 74%, and 77%, respectively. 'Distance' measures the mean class distance to the nearest elite school in kilometres from the students' home address. 8

compared to stayers, both at the individual and the class level. This difference already hints at distance being a potential “pull factor” for parents to opt out of general primary schools, in line with the literature on school choice (e.g. Burgess et al., 2015; Echenique & Yenmez, 2015; Hastings & Weinstein, 2008), and also consistent with the low residential mobility in Hungary. Measuring residential mobility as the share of people who moved to another dwelling within the last five-year period, Hungary ranks 23<sup>rd</sup> out of 28 EU countries, at a level of mobility (7.4 percent) well below the EU average (17.8 percent).<sup>10</sup> This further supports our claim that Hungary offers an interesting setting to study the effect of high achieving peers, using distance as an instrument, given the low threat of sorting into areas with elite schools.

Dividing all Hungarian schools into schools where no students left in a given year and schools where at least one student left to an elite school, we see that almost half of students are in schools where the best students are leaving. In terms of student achievement and socio-economic status, the differences between schools are less pronounced than the aforementioned differences between students. This suggests that, within general primary schools, students leaving for elite schools are the highest achievers, and leavers are not simply sorting into general primary schools before grade 6. In schools where at least one student left, the share of leavers is around 10 percent, or approximately two students in an average class in grade 6. For students in these schools, the mean distance to the nearest elite school is significantly lower compared to students in schools where no one is leaving.

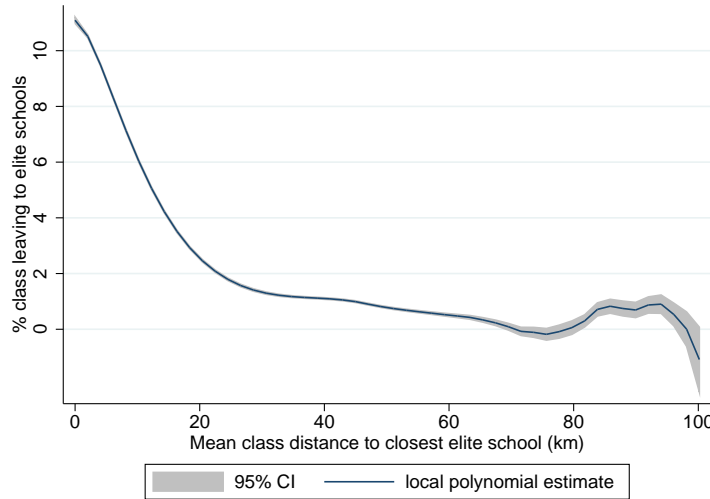
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<sup>10</sup>As per Eurostat. See: <http://ec.europa.eu/eurostat/product?code=ilc.hcmp05>

## 4 Empirical Methodology

We are interested in the causal effect of high achieving peers on students left behind in general primary education. The share of students who leave for an elite school might be endogenous to the quality of the school. Higher quality schools can either send out more students, as they offer better preparation for elite school entrance exams, or send out fewer students, as parents may prefer to avoid switching costs when quality improvements are likely to be limited. Figure 2 displays the smoothed relationship between the class-level distance to an elite school and the percentage of students leaving a class. This share decreases with distance, approaching zero as the mean class distance grows higher. As suggested by this graph, the distance to an elite school is an important determinant of high achieving students' departure to an elite school. Geographical variation in historical elite school establishment allows us to construct an instrument for the share of leavers, based on the distance to the nearest elite schools. We use this distance-induced variation in the share of leavers to estimate the causal effect on the children who were left behind.

Figure 2: Percentage of leavers in a class as a function of distance.



Notes: This figure displays a local polynomial smoothed kernel density plot of the unconditional relationship between mean class distance to elite schools and the percentage of leavers in a class.

Using Two Stage Least Squares (2SLS), we estimate the second stage:

$$Y_{ictr} = \beta_0 + \delta_{2SLS}P_{ctr} + \alpha\mathbf{X}_{ictr} + \rho_r + \phi_t + \epsilon_{ictr} \quad (1)$$

where  $Y_{ictr}$  represents the outcome variable in grade 8 of student  $i$  in class  $c$ , year  $t$ , and region  $r$ .  $P_{ctr}$  is the percentage of classroom peers enrolled in an elite school.  $\mathbf{X}_{ictr}$  includes controls both at the individual and class level (outcome

variable in grade 6, gender, socio-economic indicators, class size in grade 6).<sup>11</sup>  $\rho_r$  and  $\phi_t$  are vectors of regional and cohort fixed effects.

The corresponding first stage equation is:

$$P_{ctr} = \gamma_0 + \gamma_1 D_{ctr} + \lambda \mathbf{X}_{ctr} + \rho_r + \phi_t + \nu_{ctr} \quad (2)$$

$D_{ctr}$  represents our instrument, namely, the public transport distance to the closest elite school.<sup>12</sup>  $\mathbf{X}_{ctr}$  includes controls as in equation (1).

Three points about equations (1) and (2) are worth mentioning. First, we apply 2SLS using the class mean public transport distance to the closest elite school as an instrument. In the tables presented in Section 5, all first stage F-statistics are well above the conventional weak instruments thresholds. Additional first stage results are presented in Table B2 for various sets of controls. Consistent coefficients and F-statistics well above conventional thresholds suggest that the mean class distance to an elite school is a strong instrument for the share of students leaving for elite schools.

Second, historically, highly developed regions pushed more for the establishment of elite schools in the education market. Therefore, we include region fixed effects and exploit variation in distance within regions. In addition, we include a full set of socio-economic controls (parental education, parental employment, and number of books at home) both at the individual level and at the class level (calculated as the leave-out-mean).<sup>13</sup>

Third, it is possible that parents living far away from elite schools move close to an elite school before they choose to enrol their children. This would render our instrument invalid. In Section 5.1 (Table 2) we provide an empirical check of the assumption that students are not sorting into regions with elite schools. As discussed before, residential mobility in Hungary is extremely low. Given the rigid educational landscape since 1999 in this immobile society, the distance to elite schools should be independent of test scores *before* students leave to elite schools. Therefore, we regress the class mean distance to elite schools on mathematics and reading test scores in grade 6, conditional on individual controls, class-level controls and fixed effects. The results in Table 2 suggest there is no significant relationship between grade 6 test scores and the mean distance

<sup>11</sup>Note that we obtain analogous results when including the full set of individual characteristics reported in Table 1. This is in line with intuition as socio-economic variables are typically strongly correlated.

<sup>12</sup>Distance is measured as the class mean of the number of meters on the bus route from a student's home address (settlement code) to the elite school's location (settlement code). Hence, we observe some 'zero' distances, as elite schools can be located in a student's settlement. Our findings are robust to the alternative specification  $\gamma_1 D_{ctr} = \theta_0 D_{ctr}^0 + \theta_1 D_{ctr}$  with  $\theta_0 D_{ctr}^0 = 0$  when the mean class distance to an elite school is larger than 0. When the mean distance is 0,  $D_{ctr} = 0$  while  $D_{ctr}^0 = 1$ . Hence,  $\theta_0$  estimates the effect when the mean class distance is 0 and  $\theta_1$  otherwise.

<sup>13</sup>In Table B3 in the Appendix, we obtain similar results when repeating our analysis without cities to rule out bias from elite schools clustering in the most developed regions.

to an elite school, consistent with the exclusion restriction of our instrument.<sup>14</sup> Repeating the regressions with grade 8 test scores (reduced form), we do find a significant effect of distance on mathematics test scores. This finding supports the validity of distance as our instrument and already suggests that there is an effect of high achieving peers leaving the class.

## 5 Results

### 5.1 Main Results

Before we present the main results, one important issue is worth mentioning. The higher the fraction of leavers, the more negatively selected the sample of stayers. For this purpose, we divide the students into quartiles of the ability distribution in grade 6, where the quartile is calculated on the whole population of students. Students leaving to elite schools are high ability students, and hence mostly concentrated in the top quartile (Q1). As a result, leaving students decrease the mean Q1 scores the most, reducing the treatment effects for this subgroup. To deal with this issue, we define the sample of stayers as students who were not in Q1 pre-treatment. Therefore, our working sample in the analyses below includes students in Q2-Q4 who are left behind in primary schools. Our main analyses and corresponding appendices focus on the effect of leavers on test scores of students left behind in general primary education who were in the second, third, and fourth quartile of the ability distribution in grade 6 ( $N=365,015$ ).<sup>15</sup> Since mathematics and reading test scores are included as standardized outcome measures, the coefficients of these outcomes can be interpreted as effect sizes in terms of standard deviations.

In the falsification tests in Table 2, we show that the distance to the nearest elite school is unrelated to pupils' academic ability as measured in grade 6. Conditional on individual and class characteristics, and including region and cohort fixed effects, we cannot find a significant association between test scores in grade 6 and the class mean distance to the nearest elite school. Nonetheless, from our first stage estimates, it is clear that the mean class distance is a strong predictor of the percentage of students leaving for elite schools, even when the

<sup>14</sup>We also repeat our analysis when restricting the sample to students who did not move between grade 6 and grade 8, and find similar results (see Section 5.2 and Table B3). In addition, this result holds even if we include both the distance to an elite school that students can go to after grade 6 and the distance to an elite school that students can go to after grade 4. It is important to note, however, that elite schools where students can go to after grade 4 are not the same schools as the elite schools that students can go to after grade 6. Only two elite schools in Hungary accept students both after grade 4 and after grade 6.

<sup>15</sup>Nonetheless, the 2SLS results for the full sample that includes Q1 are consistent with the results for the working sample: a significantly negative effect for mathematics (coefficient: -0.0057, standard error: 0.0015) and an insignificant effect for reading (coefficient: -0.0014, standard error: 0.0011), although different in magnitude.

full set of controls is included: an increase of 10 kilometres in the mean class distance coincides with a decrease of about 1.5 percentage points in the share of students per class leaving for elite schools. This negative coefficient corresponds to the negative slope seen in Figure 2. Moreover, we show in Table B2 that the first stage relationship between distance and the share of leavers appears very stable across specifications. In sum, the falsification tests and the first stage findings strengthen our claim that students are not sorting into regions with elite schools.

We now turn to the results. For both outcomes, we present OLS estimates and 2SLS estimates. The naïve OLS results indicate that, on average, students left behind perform worse in mathematics and reading when they are in classes where the percentage of peers who left the class is higher. In terms of magnitude, these negative effects are modest: a 5 percentage point increase in the share of students leaving, which corresponds to one student leaving in an average class, results in a decrease of 0.008 SD and 0.006 SD in mathematics and reading, respectively. As argued before, these naïve estimates might be prone to endogeneity issues, which could bias our estimates in both directions.

Instrumenting the share of students leaving by the mean class distance indicates that students left behind perform worse in mathematics when they are in classes where the percentage of peers who left is higher. In terms of magnitude, a 5 percentage point increase in the share of students who left corresponds to a 0.038 SD reduction in mathematics test scores. In other words, in an average class, the departure of one high achieving student lowers the mean mathematics test score of the peers who were left behind by about 4 percent of a standard deviation. In contrast, we do not find a significant effect on reading. The discrepancy in 2SLS coefficients between mathematics and reading could be linked to mathematics being commonly perceived as a better proxy of ability. Hence, when the selectivity of elite schools hinges on mathematical abilities, we expect that the students who leave are particularly the ones with the highest mathematics scores, so larger effects are expected for mathematics than for reading.

Table 2: Effect of students leaving the class to an elite school on stayers' achievement by quartile of the ability distribution in grade 6

|                                   |                    | Mean                   | Quartile 2             | Quartile 3             | Quartile 4             |
|-----------------------------------|--------------------|------------------------|------------------------|------------------------|------------------------|
| <b>Mathematics</b><br>(N=365,015) | Falsification test | -0.0000<br>(0.0010)    | 0.0001<br>(0.0010)     | -0.0004<br>(0.0010)    | -0.0004<br>(0.0010)    |
|                                   | OLS                | -0.0015***<br>(0.0004) | -0.0007<br>(0.0005)    | -0.0007*<br>(0.0004)   | -0.0013***<br>(0.0004) |
|                                   | First stage        | -0.1467***<br>(0.0205) | -0.1275***<br>(0.0179) | -0.1483***<br>(0.0204) | -0.1668***<br>(0.0241) |
|                                   | 2SLS               | -0.0077**<br>(0.0039)  | -0.0104**<br>(0.0046)  | -0.0070*<br>(0.0043)   | -0.0060*<br>(0.0038)   |
|                                   | Falsification test | -0.0004<br>(0.0010)    | -0.0007<br>(0.0008)    | -0.0006<br>(0.0009)    | -0.0001<br>(0.0009)    |
|                                   | OLS                | -0.0011***<br>(0.0002) | -0.0005<br>(0.0004)    | -0.0004<br>(0.0003)    | -0.0006***<br>(0.0003) |
|                                   | First stage        | -0.1460***<br>(0.0205) | -0.1269***<br>(0.0179) | -0.1479***<br>(0.0204) | -0.1662***<br>(0.0241) |
|                                   | 2SLS               | 0.0011<br>(0.0024)     | -0.0026<br>(0.0032)    | 0.0028<br>(0.0029)     | 0.0016<br>(0.0027)     |

*Notes:* This table reports OLS and 2SLS estimates of the impact of high achieving peers leaving for elite schools (one percentage point change), first stage estimates, and a falsification test. We control for individual (previous test score, gender, maternal education, and books at home) and class level (gender, maternal education, books at home, and class size in grade 6) characteristics. Class level variables are obtained by leaving out individual observations (leave-out-mean). We also include regional and cohort fixed effects. Standard errors are clustered at the regional level. F-statistics of corresponding first stage estimates (obtained using the same set of controls) are well above conventional thresholds. 'Mean' indicates the mean result for the working sample: students in Q2-Q4 of the ability distribution in grade 6 who are left behind in primary schools. Falsification test includes a regression of grade 6 test scores on class mean distance to the nearest elite school using exactly the same specification and controls as the main regression. Quartiles are constructed using the grade 6 mean score on mathematics and reading of both stayers and leavers. For example, students in Q4 attained an average test score in the lowest quartile of all Hungarian students. \*\*\* Significant at 1% level. \*\* Significant at 5% level. \* Significant at 10% level.

## 5.2 Robustness Checks

Before further disentangling this mean effect by quartile of the ability distribution, we assess its consistency across different robustness checks.

First, we repeat our analysis using different measures of distance in Table B3 (Panel A). Using the time of the commute (by car or bus) between students' home addresses and the nearest elite school as instruments, we obtain very similar results, and all the first stage F-statistics are well above the conventional weak instruments thresholds.

Second, if students living closer to elite schools exhibit a larger growth potential in addition to higher abilities, specification bias could be driving our results. Therefore, we re-estimate the main results including second and third degree polynomials of previous test scores. The results are presented in Table B3 (Panel B). Again, coefficients obtained when (nonlinear) student growth rates are accounted for are consistent with the results in Table 2.

Third, we restrict our sample to further dismiss parallel explanations behind our results. We limit our sample to schools that retained a fixed number

of classes between grade 6 and grade 8. Focusing on this subsample allows us to rule out the possibility that the observed results are driven by students being reshuffled into new classes. Panel B of Table B3 presents the results. The coefficient obtained for mathematics is almost identical to the coefficient reported in Table 2 and the coefficient for reading remains small and insignificant, which suggests that the reshuffling effect is not driving our results.

Next, we leave out the capital, Budapest, and other major Hungarian cities to assess whether our results are driven by elite schools clustered in the most developed regions. Again, Table B3 reports results that are consistent with our main findings.

To further back our claim that distance is not endogenous to school choice in Hungary, we restrict our sample to those classes where no students moved between grade 6 and grade 8. The estimated impact of high achieving peers leaving to elite schools is similar to the estimated effect in the full sample.

As another robustness check, we limit the sample by restricting the class distance and the share of leavers to not exceed the mean by more than two standard deviations. This corresponds to a maximum distance of 45.9 kilometres, and 27.6 percent of leavers - or around five students in an average class. We do this to attenuate the influence of outliers with respect to distance to elite schools and the share of leavers in a class. Our main results are robust to these additional specifications.

As a last robustness check, we exploit the natural variation in cohort composition across time within a given school to assess our results under an alternative identification strategy. This is accomplished by focusing on schools where at least one student left in every cohort and a series of fixed effects models:

$$Y_{ist} = \psi_0 + \psi_1 P_{st} + \psi_2 \mathbf{X}_{ist} + \phi_t + \omega_s + \eta_s t + v_{ist} \quad (3)$$

Where  $P_{st}$  now measures the share of leavers at the school level and  $\mathbf{X}_{ist}$  includes school-level characteristics.  $\phi_t$ ,  $\omega_s$ , and  $\eta_s$  are cohort fixed effects, school fixed effects, and school-specific time trends.  $v_{ist}$  is the error term. Note that both approaches essentially rely on, and benefit from, parents in Hungary not moving to areas with elite schools. Distance is conceptually a valid instrument when parents do not move to send their children to elite schools, while this residential immobility also strengthens the assumption that between-cohort variation in the share of leavers is random. In contrast to other studies using between-cohort variation (e.g. Carrell & Hoekstra, 2010), the balancing test cannot hold in our setting, as the share of leavers is directly related to student characteristics. Therefore, we chose the IV method as our main empirical strategy. Nonetheless, our estimates for mathematics in Table B4 point at the same direction and are largely similar in size - but, as is common when using IV, estimates appear

Table 3: Heterogeneous treatment effects

|                    | Mean                   | Gender              |                        | Socio-Economic Status (SES) |                        |
|--------------------|------------------------|---------------------|------------------------|-----------------------------|------------------------|
|                    |                        | Boys                | Girls                  | Low SES                     | High SES               |
| <b>Mathematics</b> | -0.0077***<br>(0.0039) | -0.0056<br>(0.0038) | -0.0099***<br>(0.0017) | -0.0103<br>(0.0070)         | -0.0099***<br>(0.0026) |
| <b>Reading</b>     | 0.0011<br>(0.0024)     | 0.0014<br>(0.0027)  | 0.0006<br>(0.0028)     | 0.0006<br>(0.0046)          | -0.0045*<br>(0.0025)   |

*Notes:* This table reports 2SLS estimates of the impact of high achieving peers leaving for elite schools (one percentage point change). We control for individual (previous test score, gender, maternal education, and books at home) and class level (gender, maternal education, books at home, and class size in grade 6) characteristics. Class level variables are obtained by leaving out individual observations (leave-out-mean). We also include regional and cohort fixed effects. Standard errors are clustered at the regional level. F-statistics of corresponding first stage estimates (obtained using the same set of controls) are well above conventional thresholds. 'Mean' indicates the mean result presented in Table 2. \*\*\* Significant at 1% level. \* Significant at 10% level.

somewhat amplified (Bingley & Martinello, 2017).<sup>16</sup> The estimates for reading, however, are significantly negative and should be interpreted with caution as the balancing test does not hold when using between-cohort variation. Also note that the heterogeneous effects by ability, discussed below, are similar when using between-cohort variation in the share of leavers (Figure A1 in the Appendix).

### 5.3 Heterogeneous Effects

Despite this robust mean effect, it might be that heterogeneous effects with opposite directions result in lower average treatment effects. Therefore, we estimate the 2SLS model for various subgroups. Table 2 reports effects for every quartile of the ability distribution. Quartiles are constructed using the grade 6 mean score on mathematics and reading. As is clear from Table 2, negative effects on mathematics test scores are especially pronounced among high achievers left behind (Q2). In terms of magnitude, mathematics test scores for Q2 students reduce by about 0.05 SD when one student leaves (around 5 percent) to an elite school. On the other hand, the effect on reading test scores is insignificant regardless of the quartile.

Table 3 presents heterogeneous effects by gender and socio-economic status (SES). We define low SES students as those students whose mothers attained at most a secondary education degree. High SES students' mothers attained at least a Bachelor's degree. For mathematics, it can be seen that high SES

<sup>16</sup>As suggested by an anonymous referee, we ran the IV estimation on the same set of schools as the fixed effects estimation. The effects are consistent with the main specification albeit larger and with inflated standard errors due to a restricted sample: -0.0151 (0.0088) for mathematics and -0.0069 (0.0062) for reading.

students and girls are negatively affected, with the effect of one leaving student of about 0.05 SD decrease in grade 8 test scores. On the contrary, effects are not different from zero for boys and low SES students. For reading, only high SES students are negatively affected by about 0.02 SD for one student leaving. Also, the gender of those who are leaving the class to elite schools does not seem to affect the estimated effects (Table B5).

#### 5.4 Alternative Outcomes

For a subsample of students, we also observe GPA scores (64%), behavioural assessments by teachers (74%), and students' aspirations for higher education (77%). Due to this selective reporting by teachers, students' alternative outcomes are likely affected by the class composition. For instance, more 'potential leavers' in a class could raise the bar, leading to higher teacher expectations, and lower GPA scores for those left behind. Consequently, the balancing tests for alternative outcomes are unlikely to hold. Conducting the balancing tests in Table B6, we find that this indeed is the case for GPA and behaviour.<sup>17</sup> In classes further away from elite schools, and hence with less potential leavers, students left behind receive better teacher evaluations for GPA and aspirations in grade 6. Hence, sufficient caution is required when interpreting our findings for alternative outcomes.

Table 4 presents mean effects, and treatment effects by quartile in terms of ability in grade 6, as in Table 2. We only find a significant effect of students leaving on the higher education aspirations of stayers in Quartile 3. In terms of magnitude, one student leaving to an elite school increase Q3 students' higher education aspirations by about 1.5 percentage points. Most other effects are insignificant and range from about 0 to 1 percentage point in magnitude.

Table 5 presents heterogeneous effects by gender and socio-economic status (SES). We find negative effects on behaviour that are more pronounced for girls and high SES students, while effects for boys and low SES students are insignificantly different from zero. The magnitude of the effects is close to zero for GPA and aspirations, while the negative effect on behaviour for girls (high SES students) amounts to about 3 (2.5) percentage points.

In sum, our main results hide considerable heterogeneity by students' gender and socio-economic background. We find that the departure of high achieving students to elite schools negatively impacts girls, and high achieving students who are left behind, alongside student from a similar socio-economic background (high SES) as the students who left.

<sup>17</sup>We are grateful to an anonymous referee for suggesting these additional balancing tests.

## 6 Discussion

Typically, one or two students leave their class to elite schools. This limited change in class size is unlikely to explain the size of the effects. Restricting the number of leavers in Table B3 did not affect our estimates, which suggests that class size changes are not the (main) driver of the observed effects. Using the class size effects on student achievement from the literature, ranging from about 2 percent to about 6 percent of a standard deviation (Angrist & Lavy, 1999; Bressoux et al., 2009; Fredriksson et al., 2013; Heinesen, 2010; Jepsen & Rivkin, 2009; Krueger, 1999), with the exception of Hoxby (2000) who finds no effects, our negative peer effects would become even larger, ranging from about 6 percent to about 10 percent of a standard deviation. Hence, our results represent a lower bound.

Looking at heterogeneous effects, we found that negative effects are concentrated among high ability, high SES students and girls left behind. The latter effect can be linked to previous studies indicating that girls benefit more from education inputs and interventions in general (Angrist et al., 2009; Katz et al., 2001), and in particular benefit more from brighter peers (Lavy et al., 2012). Given the similarity between high SES, high ability students and the students leaving, it is likely that micro-interactions are at play within subclassroom groups (Lu & Anderson, 2015).

Table 4: Effect of students leaving the class to an elite school on stayers' alternative outcomes by quartile of the ability distribution in grade 6

|                                   | Mean                | Quartile 2          | Quartile 3          | Quartile 4          |
|-----------------------------------|---------------------|---------------------|---------------------|---------------------|
| <b>GPA</b><br>(N=222,703)         | -0.0010<br>(0.0020) | 0.0012<br>(0.0027)  | -0.0003<br>(0.0022) | -0.0027<br>(0.0024) |
| <b>Behaviour</b><br>(N=263,895)   | -0.0019<br>(0.0019) | -0.0032<br>(0.0027) | -0.0008<br>(0.0025) | -0.0006<br>(0.0024) |
| <b>Aspirations</b><br>(N=276,008) | 0.0012<br>(0.0011)  | 0.0020<br>(0.0017)  | 0.0027*<br>(0.0016) | -0.0006<br>(0.0011) |

*Notes:* This table reports 2SLS estimates of the impact of high achieving peers leaving for elite schools (one percentage point change). 'GPA' is the grade point average, graded by the teacher. 'Behaviour' is measured as a Likert scale (1-5), graded by the teacher, with higher scores indicating better behaviour. 'Aspirations' represents a dummy indicating students' response to the survey question asking whether he or she aims to enrol in higher education. We control for individual (previous test score, gender, maternal education, and books at home) and class level (gender, maternal education, books at home, and class size in grade 6) characteristics. Class level variables are obtained by leaving out individual observations (leave-out-mean). We also include regional and cohort fixed effects. Standard errors are clustered at the regional level. F-statistics of corresponding first stage estimates (obtained using the same set of controls) are well above conventional thresholds. 'Mean' indicates the mean result for the working sample: students in Q2-Q4 of the ability distribution in grade 6 who are left behind in primary schools. Quartiles are constructed using the grade 6 mean score on mathematics and reading of both stayers and leavers. For example, students in Q4 attained an average test score in the lowest quartile of all Hungarian students. Main results are robust when restricting the sample to students where alternative outcomes were observed. \* Significant at 10% level.

Table 5: Heterogeneous treatment effects for alternative outcomes

|                    | Mean                | Gender              |                        | Socio-Economic Status (SES) |                       |
|--------------------|---------------------|---------------------|------------------------|-----------------------------|-----------------------|
|                    |                     | Boys                | Girls                  | Low SES                     | High SES              |
| <b>GPA</b>         | -0.0010<br>(0.0020) | -0.0006<br>(0.0022) | -0.0015<br>(0.0014)    | -0.0019<br>(0.0046)         | 0.0003<br>(0.0020)    |
| <b>Behaviour</b>   | -0.0019<br>(0.0019) | 0.0028<br>(0.0026)  | -0.0064***<br>(0.0015) | -0.0005<br>(0.0039)         | -0.0050**<br>(0.0023) |
| <b>Aspirations</b> | 0.0012<br>(0.0011)  | 0.0019<br>(0.0013)  | 0.0003<br>(0.0011)     | 0.0003<br>(0.0020)          | 0.0007<br>(0.0017)    |

*Notes:* This table reports 2SLS estimates of the impact of high achieving peers leaving for elite schools (one percentage point change). ‘Mean’ indicates the mean result presented in Table 4. ‘GPA’ is the grade point average, graded by the teacher. ‘Behaviour’ is measured as a Likert scale (1-5), graded by the teacher, with higher scores indicating better behaviour. ‘Aspirations’ represents a dummy indicating students’ response to the survey question asking whether he or she aims to enrol in higher education. We control for individual (previous outcome variable, gender, maternal education, and books at home) and class level (gender, maternal education, books at home, and class size in grade 6) characteristics. Class level variables are obtained by leaving out individual observations (leave-out-mean). We also include regional and cohort fixed effects. Standard errors are clustered at the regional level. ‘Mean’ indicates the mean result presented in Table 4. F-statistics of corresponding first stage estimates (obtained using the same set of controls) are well above conventional thresholds. \*\*\* Significant at 1% level. \*\* Significant at 5% level.

These negative effects might stem from losing a close peer. High ability students left behind, who likely applied as well, might then be discouraged as their close peers left to an elite school while they did not. However, this possible explanation is inconsistent with the results on the impact of same versus different gender peers leaving the class obtained in Table B5. Many papers from psychology and sociology have documented that friendships in primary and middle-schools are mainly within the same gender (Kovacs et al., 1996; Mehta & Strough, 2009; Miller et al., 2001; Poulin & Pedersen, 2007; Shrum et al., 1988). Thus, we would expect a larger effect on boys when another boy leaves, as well as a larger effect on girls when another girl leaves. Results in Table B5, however, suggest otherwise. We observe that the effects on both boys and girls are larger when a girl leaves than when a boy leaves the class. Therefore, it is unlikely that the negative impact of losing a direct friend is driving our results.

## 7 Conclusion

The effect of high achieving peers on student achievement is at the core of many educational discussions on issues such as ability tracking or school segregation (Card & Giuliano, 2016; Guyon et al., 2012). We provide novel evidence on this effect by exploiting changes in class composition due to the departure of high achieving students to elite schools. Our results suggest that their departure has a negative effect on the students who are left behind in general primary education,

on average. In particular, we find that an increase of 5 percentage points in the share of students who left (i.e., one additional high achieving student leaving) leads to a reduction in mathematics test scores by 0.04 standard deviations. We find no effect for reading, on average.

The overall results hide considerable heterogeneity. We observe that the mean negative effect is mostly driven by high ability students left behind, by girls, and by students with a high socio-economic status. For a subsample of students where teacher-graded GPA, behaviour, and higher education aspirations were observed we generally do not find significant effects.

It should be noted that we did not evaluate the outcomes of the students who left to an elite school. A potential positive effect experienced by those students might offset the moderate negative effects presented here. Also, the share of students leaving for an elite school is rather limited in Hungary, amounting to 6 percent in an average class. This corresponds to just over one student on average, far from ability tracking structures often present in secondary of higher education. Therefore, mean effects estimated in this paper might be larger in settings where children left behind are facing more severe shocks in peer composition.

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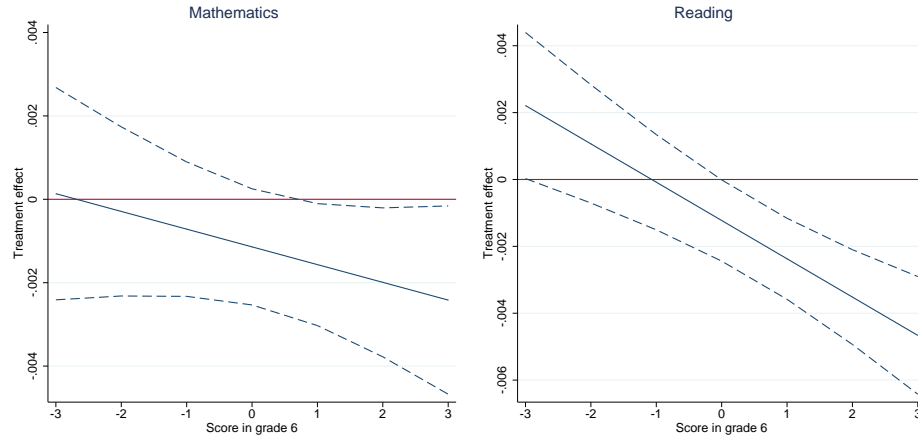
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## Appendix A: Figures

Figure A1: Treatment effect of 1% leavers on stayers, by ability in grade 6.



*Notes:* This figure displays the interaction between test scores in grade 6 of students left behind in general primary schools and the impact of high achieving peers leaving to elite schools on grade 8 test scores. Treatment effects reflect the impact of a 1% increase in the share of leavers in a school, as reported in Table B4, by ability in grade 6. We control for individual (previous test score, gender, maternal education, and books at home) and school level (gender, maternal education, books at home, and school size in grade 6) characteristics. School level variables are obtained by leaving out individual observations (leave-out-mean). Standard errors are clustered at the school level. The estimated model also includes cohort fixed effects, school fixed effects, and school-specific time trends. 95% confidence intervals are constructed using standard errors clustered at the regional level.

## Appendix B: Tables

Table B1: Comparison of leavers to reference group

| Distribution of leavers (N=26,823) by: |                  | -2 SD | -1 SD | Mean  | +1 SD | +2 SD |
|--|------------------|-------|-------|-------|-------|-------|
| <b>Class</b>                           |                  | 98.78 | 92.23 | 71.65 | 36.34 | 9.65  |
|  | (relative share) | 6.63  | 20.85 | 35.74 | 27.02 | 9.77  |
| <b>School</b>                          |                  | 99.23 | 94.52 | 76.44 | 39.73 | 10.39 |
|  | (relative share) | 4.75  | 18.23 | 36.99 | 29.56 | 10.47 |
| <b>Settlement (ZIP)</b>                |                  | 99.43 | 96.26 | 79.29 | 39.27 | 8.07  |
|  | (relative share) | 3.19  | 17.11 | 40.22 | 31.36 | 8.11  |
| <b>Region</b>                          |                  | 99.93 | 98.61 | 87.27 | 48.95 | 10.12 |
|  | (relative share) | 1.32  | 11.35 | 38.35 | 38.85 | 10.13 |
| <b>Cohort</b>                          |                  | 99.97 | 98.89 | 88.44 | 51.91 | 40.97 |
|  | (relative share) | 1.09  | 10.45 | 36.54 | 40.95 | 10.97 |

*Notes:* All numbers are measured as percentages. They reflect the share of leavers that outperforms their respective reference group. Outperforming is indicated having a test score for either reading or mathematics above the cutoff level (columns). For example, 88.44 percent of leavers outperforms the cohort average test score. This group can be disentangled by students that score above 2 SD (10.97%), above 1 SD (40.95%) and above the mean - but less than 1 SD - (36.54%).

Table B2: Robustness of distance as an instrument

| First stage: % students in a class leaving for elite schools |                        |                        |                        |                        |                        |                        |
|--|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
|  | (1)                    | (2)                    | (3)                    | (4)                    | (5)                    | (6)                    |
| <b>Mathematics</b>   |                        |                        |                        |                        |                        |                        |
| Distance (km)  | -0.1923***<br>(0.0217) | -0.1924***<br>(0.0217) | -0.1804***<br>(0.0165) | -0.2111***<br>(0.0229) | -0.1467***<br>(0.0205) | -0.2221***<br>(0.0246) |
| F-statistic  | 78.52                  | 78.79                  | 119.07                 | 84.98                  | 51.23                  | 81.21                  |
| <b>Reading</b>   |                        |                        |                        |                        |                        |                        |
| Distance (km)  | -0.1923***<br>(0.0217) | -0.1924***<br>(0.0217) | -0.1789***<br>(0.0160) | -0.2093***<br>(0.0228) | -0.1460***<br>(0.0205) | -0.2221***<br>(0.0246) |
| F-statistic  | 78.52                  | 78.79                  | 125.28                 | 84.61                  | 50.61                  | 81.21                  |
| Individual   |                        |                        | Yes                    | Yes                    | Yes                    |                        |
| Class level  |                        |                        | Yes                    | Yes                    | Yes                    | Yes                    |
| Cohort FE  |                        | Yes                    |                        | Yes                    | Yes                    | Yes                    |
| Region FE  |                        |                        |                        | Yes                    | Yes                    | Yes                    |
| Students   | 365,015                | 365,015                | 365,015                | 365,015                | 365,015                | 365,015                |

Notes: This table reports OLS (first stage) estimates of the relationship between the mean class distance and the percentage of students leaving a class, for various sets of control variables. Individual controls include a student's previous test score, maternal education, and books at home. Class level controls includes the class size in grade 6 and individual level controls averaged at class level (leaving one out). Standard errors are clustered at regional level. F-statistics of corresponding first stage estimates (obtained using the same set of controls) are well above conventional thresholds. \*\*\* Significant at 1% level.

Table B3: Additional robustness checks

| Panel A: Distance to nearest elite school (class mean) |                       |                      |
|--|-----------------------|----------------------|
|  | Time by bus (min)     | Time by car (min)    |
| Mathematics  | -0.0075**<br>(0.0038) | -0.0056*<br>(0.0034) |
| Reading  | 0.0020<br>(0.0024)    | 0.0015<br>(0.0023)   |

| Panel B: Alternative specifications |                          |                                       |  |
|-------------------------------------|--------------------------|---------------------------------------|--|
|                                     | Growth                   | Reshuffling<br>(N=338,409)            | No cities<br>(N=177,214)               |
| Mathematics                         | -0.0078**<br>(0.0039)    | -0.0073*<br>(0.0049)                  | -0.0105***<br>(0.0014)                 |
| Reading                             | 0.0019<br>(0.0035)       | 0.0011<br>(0.0028)                    | 0.0061<br>(0.0100)                     |
|                                     | No movers<br>(N=258,289) | No outliers (distance)<br>(N=342,372) | No outliers (% leaving)<br>(N=355,009) |
| Mathematics                         | -0.0075*<br>(0.0045)     | -0.0060*<br>(0.0036)                  | -0.0101*<br>(0.0057)                   |
| Reading                             | 0.0020<br>(0.0031)       | 0.0022<br>(0.0024)                    | 0.0023<br>(0.0034)                     |

*Notes:* Panel A reports 2SLS estimates of the impact of high achieving peers leaving for elite schools (one percentage point change), for different distance measures as instrumental variables. Panel B reports 2SLS estimates of the impact of high achieving peers leaving for elite schools, for different specifications. The ‘reshuffling’ effect is tested by limiting the sample to those schools that retained a fixed number of classes between grade 6 and grade 8. Student growth (‘Growth’) is accounted for by including second and third degree polynomials of the previous test score as control variables. ‘No cities’ restricts the sample to schools located outside of Budapest and other locations classified as a city. ‘No movers’ restricts the sample to classes where no one moved between grade 6 and grade 8. ‘No outliers (distance)’ and ‘No outliers (% leaving)’ restrict the sample to classes where the median distance to the nearest elite schools, and the share of leavers to an elite school, respectively, is less than two standard deviations above the mean. When obtaining all the above estimates, we control for individual (previous test score, maternal education, and books at home) and class level (gender, maternal education, books at home, and class size in grade 6) characteristics. We also include regional and cohort fixed effects. Standard errors are clustered at the regional level. F-statistics of corresponding first stage estimates (obtained using the same set of controls) are well above conventional thresholds. Variation in the number of observations is due to sample selection procedures described above. \*\*\* Significant at 1% level. \*\* Significant at 5% level. \* Significant at 10% level.

Table B4: Treatment effects using between-cohort variation

|                             | 2SLS                  | Cohort variation       |                        |                       |
|-----------------------------|-----------------------|------------------------|------------------------|-----------------------|
|                             |                       | (1)                    | (2)                    | (3)                   |
| <b>Mathematics</b>          | -0.0077**<br>(0.0039) | -0.0027***<br>(0.0005) | -0.0015**<br>(0.0008)  | -0.0010<br>(0.0008)   |
| <b>Reading</b>              | 0.0011<br>(0.0024)    | -0.0027***<br>(0.0004) | -0.0018***<br>(0.0006) | -0.0015**<br>(0.0007) |
| Cohort FE                   |                       | Yes                    | Yes                    | Yes                   |
| School FE                   |                       |                        | Yes                    | Yes                   |
| School-specific time trends |                       |                        |                        | Yes                   |
| N                           | 365,015               | 94,760                 | 94,760                 | 94,760                |

*Notes:* This table reports estimates of the impact of high achieving peers leaving for elite schools, using between-cohort variation in the percentage of peers leaving within a school. We restrict our sample to schools where at least one student left in every observed cohort within that school. '2SLS' represents the mean effect presented in Table 2. We control for individual (previous test score, gender, maternal education, and books at home) and school level (gender, maternal education, books at home, and school size in grade 6) characteristics. School level variables are obtained by leaving out individual observations (leave-out-mean). Standard errors are clustered at the school level. \*\*\* Significant at 1% level. \*\* Significant at 5% level.

Table B5: Heterogeneous treatment effects by gender of leaving students

|                    | Boys leaving          |                     |                        | Girls leaving         |                     |                        |
|--------------------|-----------------------|---------------------|------------------------|-----------------------|---------------------|------------------------|
|                    | Mean                  | Boys                | Girls                  | Mean                  | Boys                | Girls                  |
| <b>Mathematics</b> | -0.0066**<br>(0.0034) | -0.0047<br>(0.0031) | -0.0090**<br>(0.0040)  | -0.0091**<br>(0.0046) | -0.0071<br>(0.0047) | -0.0112**<br>(0.0049)  |
| <b>Reading</b>     | 0.0008<br>(0.0021)    | 0.0011<br>(0.0023)  | 0.0005<br>(0.0025)     | 0.0011<br>(0.0028)    | 0.0017<br>(0.0034)  | 0.0006<br>(0.0031)     |
| <b>GPA</b>         | -0.0010<br>(0.0017)   | -0.0005<br>(0.0019) | -0.0014<br>(0.0022)    | -0.0014<br>(0.0024)   | -0.0007<br>(0.0028) | -0.0018<br>(0.0029)    |
| <b>Behaviour</b>   | -0.0019<br>(0.0016)   | 0.0023<br>(0.0021)  | -0.0059***<br>(0.0020) | -0.0026<br>(0.0022)   | 0.0035<br>(0.0032)  | -0.0073***<br>(0.0026) |
| <b>Aspirations</b> | 0.0008<br>(0.0009)    | 0.0016<br>(0.0011)  | 0.0003<br>(0.0013)     | 0.0012<br>(0.0013)    | 0.0024<br>(0.0017)  | 0.0003<br>(0.0016)     |

*Notes:* This table reports 2SLS estimates of the impact of high achieving peers leaving for elite schools (one percentage point change) separately by gender of those leaving general primary education. We control for individual (previous test score, maternal education, and books at home) and class level (gender, maternal education, books at home, and class size in grade 6) characteristics. We also include regional and cohort fixed effects. Standard errors are clustered at the regional level. The percentage of a student's male or female peers leaving the class is instrumented by boys' and girls' average distance to elite schools, respectively. F-statistics for all corresponding first stage estimates are well above conventional thresholds. Standard errors are clustered at the class level. 'Mean' indicates the mean result for the working sample: students in Q2-Q4 of the ability distribution in grade 6 who are left behind in primary schools. \*\*\* Significant at 1% level. \*\* Significant at 5% level.

Table B6: Falsification tests for alternative outcomes

|                                     | GPA Grade 6          | Behaviour Grade 6  | Aspirations Grade 6    |
|-------------------------------------|----------------------|--------------------|------------------------|
| Mean distance to elite schools (km) | 0.0011**<br>(0.0005) | 0.0008<br>(0.0006) | -0.0010***<br>(0.0003) |
| Individual controls                 | Yes                  | Yes                | Yes                    |
| Class level controls                | Yes                  | Yes                | Yes                    |
| Fixed Effects                       | Yes                  | Yes                | Yes                    |

*Notes:* Individual controls include students' gender, maternal education and the number of books at home. Class level controls include the same variables averaged at the class level (leave-out-mean) and the class size in grade 6. Fixed effects include cohort and regional fixed effects. Standard errors are clustered at the regional level. \*\*\* Significant at 1% level. \*\* Significant at 5% level.