Peer Effects in Education

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Abstract

The identification of peer effects is challenging. There are many factors not related to social influences that could explain correlations among peers. This article discusses the main challenges for the identification of peer effects, describes some of the empirical strategies commonly used to overcome these challenges, and summarizes the main findings of the literature on peer effects in education. Peers have been shown to affect many important outcomes, including academic performance and educational trajectories. Confirming the existence of peer effects is important from a policy perspective. Both the cost-benefit analysis and the design of policies are likely to be affected by the existence of social spillovers. However, making general policy recommendations from the current evidence is not easy. The size of the peer effects documented in the literature varies substantially across settings and depending on how peers are defined and characterized. Understanding what is behind this heterogeneity is thus key to extract more general policy lessons. Access to better data and the ability to map social networks will likely facilitate investigating which peers and which characteristics matter the most in different contexts. Conducting more research on the mechanisms behind peer effects is also important. Understanding these drivers is key to take advantage of social spillovers in the design of new educational programs, to identify competing policies, and to gain a deeper understanding of the nature and relevance of different forms of social interactions for the youth.

Key words: *peer effects, sibling effects, neighbor effects*

Introduction

Correlations among peers are well established in social sciences. Individuals attending school together, living near each other, or growing up in the same family are likely to behave similarly and to follow similar paths. Although these descriptive associations are often attributed to peer effects, there are multiple other reasons that could explain them.

Firstly, social groups are not formed at random. Therefore, similarities in peers' outcomes could be explained by the variables determining the formation of peer groups in the first place. In addition, even if social groups were formed at random, correlations among peers could be a consequence of them facing similar circumstances and shocks. Distinguishing the effect of social interactions from these alternative explanations is challenging. Therefore, confirming the existence of peer effects is already an achievement. There is, however, an additional challenge that is important to overcome to fully understand the nature of peer effects. Peer effects can be driven by contextual effects—i.e., effects of peer characteristics—or by endogenous effects—i.e., effects of peer outcomes. If the outcomes of peers simultaneously affect each other it is difficult to separate contextual and endogenous peer effects. This is what Manski (1993) defined as the reflection problem.

This paper starts by discussing the main identification and empirical challenges around the estimation of peer effects, and some empirical strategies commonly used to overcome them. It then describes the main findings of the literature on peer effects in education distinguishing between three types of peers: schoolmates, siblings, and neighbors. It concludes by discussing policy implications and some promising areas for future research.

Peer effects in education have been vastly studied. The evidence accumulated in the last decades indicates that peers impact a variety of important outcomes including test scores, educational attainment, the education institutions that individuals attend, and the fields in which they specialize.

Confirming the existence of peer effects is important from a policy perspective. Their existence indicates that many cost-benefit analyses should be adjusted and suggests that students' outcomes could be improved by modifying the social composition of schools and neighborhoods. The existence of peer effects also suggests that social networks could be used to amplify the effect of educational

programs, something that could be incorporated into their design. However, with the current evidence, it is difficult to make general policy recommendations. The size of the peer effects found in the literature varies substantially depending on the context and on how peers are defined and characterized in each study.

It is therefore important to make efforts to gain a deeper understanding of the relative importance of the various forms of social interactions experienced by youths and of the mechanisms behind peer effects. This would not only allow extracting more general policy lessons, but also identifying competing policies that could replicate the benefits of exposure to better peers without necessarily altering the composition of peer groups.

Access to better data on social groups offers great opportunities for future research. It should facilitate identifying which peers and which characteristics matter the most in different contexts. In addition, recent developments in the modeling of social networks could also help to understand how to take advantage of social spillovers in the design of educational policies to maximize their impact.

The rest of the paper is organized into four sections. Section discusses the main identification challenges of peer effects and describes credible identification strategies designed to overcome them. Section presents the main findings of the literature on peer effects in education, distinguishing between peer effects on academic performance, educational trajectories, and other relevant outcomes. Section discusses some policy implications and avenues for future research. Finally, Section concludes.

Identification of Peer Effects

Empirical Challenges

The identification of peer effects is challenging (Manski, 1993, 1995; Angrist, 2014). Firstly, peer groups are not formed at random, and therefore similarities in peer outcomes are likely to be at least in part a consequence of the common factors that made individuals to become peers in the first place. Secondly, even if peer groups are formed at random, the fact that peers experience similar circumstances and shocks makes it difficult to distinguish whether correlations in outcomes

reflect social interactions or the effect of other variables affecting the outcomes of the members of a peer group. Finally, if the outcomes of peers simultaneously affect each other, then distinguishing between contextual effects—i.e., effects of peer characteristics—and endogenous effects—i.e., effects of peer outcomes—becomes difficult. This is what Manski (1993, 1995) described as the reflection problem.

Manski (1993) proposes a simple framework to illustrate these challenges. Although the study discusses these challenges in the context of peer effects and students' test scores, it can be generalized to any other outcome. Each student is characterized by her test score (y), variables describing her peer group such as a specific school cohort (x), variables directly affecting test scores such as socioeconomic status (z), and unobserved variables also affecting test scores such as ability (ε). Assuming linearity, the following expression summarizes the relationship between these variables:

$$y = \beta_0 + \beta_1 \cdot E(y|x) + \beta_2 \cdot E(z|x) + \beta_3 \cdot z + \varepsilon \tag{1}$$

Here, $E(y|x)$ is the outcome mean in the peer group, and $E(z|x)$ is the mean of a relevant peer characteristic (e.g., socioeconomic status). Note that z could also represent a vector of multiple peer characteristics. By further assuming that $E(\varepsilon|x,z) = \beta_4 \cdot x$, the linear regression of y on (x,z) can be expressed as:

$$E(y|x,z) = \beta_0 + \beta_1 \cdot E(y|x) + \beta_2 \cdot E(z|x) + \beta_3 \cdot z + \beta_4 \cdot x \tag{2}$$

In this expression, β_1 captures endogenous peer effects, β_2 contextual peer effects, and β_4 correlated effects that arise either because the members of the same peer group have similar unobserved characteristics or because they face similar environments. β_3 captures the direct effect of z on y. Integrating both sides of expression (2) with respect to z and re-arranging some terms leads to the following expression:

$$E(y|x) = \frac{\beta_0}{1-\beta_1} + \frac{\beta_2 + \beta_3}{1-\beta_1} \cdot E(z|x) + \frac{\beta_4}{1-\beta_1} \cdot x \tag{3}$$

Now (3) can be inserted in (2) to write the reduced form model as follows:

$$E(y|x,z) = \frac{\beta_0}{1-\beta_1} + \frac{\beta_2 + \beta_1\beta_3}{1-\beta_1} \cdot E(z|x) + \frac{\beta_4}{1-\beta_1} \cdot x + \beta_4 \cdot z \tag{4}$$

From (4) it is clear that endogenous (β_1) and contextual (β_2) peer effects cannot be separately identified. It is possible, however, to determine whether social interactions do play a role. If the second term of expression (4) is different from zero, then β_1 or β_2 must be different from zero. In other words, only counting with exogenous variation in peer group composition allows us to assess whether peers matter, but it is not enough to distinguish between the contribution of peer background and peer outcomes to the overall effect. The ability to identify this composite parameter depends on the relationship between z and x. It cannot be identified if z is a function of x, $E(z|x)$ does not vary with x, or $E(z|x)$ is a linear function of x.

On top of the identification challenges described above, the estimation of peer effects requires overcoming a key empirical challenge: counting with data on peer group composition. Data with granular information on social connections are scarce. This means that in many cases, researchers are forced to use broad definitions of peers (e.g., all the students in a classroom or neighbors living in a large area). The level of aggregation used to define peer groups is important. Aggregating too much might dilute important peer effects. In addition, as pointed out by Hoxby and Weingarth (2005), peer effects are not necessarily linear in means. Although the simplicity of the linear-in-means model is appealing, it is unlikely to be an accurate representation of reality. If peer effects were indeed linear in means, then the average level of outcomes would not be affected by changes in the allocation of individuals to peer groups. Thus, the most relevant policy implications of peer effects rely on non-linear models in which not all individuals affect and are affected by their peers in the same way. Counting with more granular information allows studying non-linearities and heterogeneity in more detail. Note that to study non-linearities it is also important to count with enough variation in peer group composition, something that in many contexts is challenging.

Credible Identification Strategies

This section describes some of the empirical approaches commonly used to identify peer effects. It focuses on the strategies that have been more successful in providing credible estimates of peer effects in education and in terms of publication in peer-reviewed journals.

Changes in peer group composition: A first approach commonly used to estimate peer effects in the classroom consists in exploiting within-school variation in the characteristics of the peers to which consecutive cohorts of students are exposed. This approach requires counting with longitudinal administrative data. The key assumption behind this strategy is that the changes in the characteristics of the students who enroll in a school in consecutive years are as good as random (i.e., there are no variables simultaneously affecting the characteristics of the students who attend a school and the outcome of interest).

A second approach that has gained popularity in recent years consists in exploiting variation in peer group composition generated by quasi-experiments. Examples of quasi-experiment used to estimate peer effects include natural disasters—e.g., Hurricanes Katrina and Rita, and the 2010 earthquakes in Chile and Haiti—, desegregation programs (e.g., METCO), and changes in peer characteristics induced by admission cutoffs at oversubscribed schools or colleges. There are also a few studies exploiting random variation in the allocation of students to college dorms.

Finally, some researchers directly manipulate peer group composition through randomized control trials (RCT). Duflo et al. (2011a), for instance, randomly allocate primary school students to either homogeneous (i.e., tracking) or mixed ability classes in Kenya. Carrell et al. (2013) do something similar with the composition of squadrons in the US Air Force Academy, while Booij et al. (2017) varies the composition of tutorial groups for undergraduate students in economics.

These approaches allow distinguishing between correlated and social interaction effects. They do not, however, allow separating contextual and endogenous peer effects.[1] This is not necessarily a problem. The reduced form parameter estimated through these approaches is an interesting parameter in itself and can still be informative for the design of policies.

[1]Many studies estimate peer effects using specifications in which endogenous effects are assumed to be zero. If the assumption is wrong, then peer effects estimates are likely to be biased unless the characteristics of peers being studied are orthogonal to their outcomes.

In the case of studies exploiting variation in peer group composition generated by natural experiments, there is an additional challenge. This type of approach requires being able to separate the effect of changes in peers from the effect of other changes generated by the natural experiments. For instance, in the case of natural disasters, affected students are reallocated to new schools. The schools receiving displaced students experience a change in the characteristics of their pupils, but also in other variables that could impact the outcomes of interest (e.g., class size, per capita school resources).

Shocks affecting peers: Another approach that has become popular in recent years consists in taking peer groups as given and exploiting variation generated by random or induced shocks that affect the outcomes of one or more peers. Common examples of this type of shock include admission to oversubscribed schools or colleges. If a peer admission to a school has a random component, it can then be exploited to estimate the effect of having a peer attending such school by comparing individuals whose peers were and were not admitted to it.

Although in some cases it is possible to find shocks naturally affecting a fraction of the members of a peer group, this is something that can also be induced through RCTs. Babcock and Hartman (2010); Duflo and Saez (2003); Avvisati et al. (2014), for instance, respectively study spillovers of interventions that encouraged university students to exercise, university employees to attend an informative session on retirement plans, and parents to get more involved in their children's education. These studies consider a pure control group and only treat a fraction of the members of the treatment group. This feature of their research design allows them to study as well indirect effects of the interventions on the connections of the treated individuals.

A nice feature of this type of approach is that in contrast to the strategies discussed earlier in this section, it makes it possible to independently identify endogenous peer effects. In addition, this type of approach can be used to study heterogeneous peer effects in a very granular way.

Peer value-added: Finally, recent studies have estimated peer effects using an approach that builds on the teacher value-added literature. These papers instead of trying to understand the effect of specific peer characteristics on individual outcomes, estimate the contribution that individual students or groups of students make to their peers. From these estimates, it is difficult to tell which

peer characteristics are relevant because they capture the effect of a bundle of characteristics. However, they are useful to have an idea on how large peer effects can be independently of the characteristics of peers that drive them.

What do we know about peer effects in education?

This section summarizes the main findings of the literature on peer effects in education. It first discusses papers looking at peer effects on academic performance. It continues by discussing studies focusing on the effect of peers on educational choices and trajectories. It concludes by discussing the evidence on peer effects on other outcomes. This last part focuses on evidence on peer effects that arise in educational contexts or that affect the trajectories of individuals of school age.

The discussion distinguishes between three types of peers—schoolmates, siblings, and neighbors—and covers the evidence on peer effects from elementary school up to college.

The social interactions that take place in the school, in the family, and in the neighborhood differ substantially in their nature and intensity. These differences might be important for the potential influence that schoolmates, siblings, and neighbors have on students' outcomes.

Most of the interactions with classmates take place within educational institutions. They are, in general, well-structured and supervised by teachers and other adults. Typically, students are not equally close to all their classmates. Therefore, the interactions with classmates are likely to mask substantial heterogeneity. Siblings, on the other hand, are perhaps the most relevant members of our social networks during infancy and adolescence. The amount of time that siblings spend together and all what they share in the household makes their relationship quite unique. Sibling spillovers might arise as a consequence of direct interactions, but also as a consequence of parents' actions (e.g., spending extra time and resources supporting children that struggle more at school). Finally, social interactions between neighbors largely depend on the setting and on the ties that exist within a community. Thus, identifying who are the relevant peers within a neighborhood is particularly challenging. By discussing the evidence on these three types of peers, this article aims to contribute to achieving a deeper understanding of their relevance for different outcomes and to shed some light on potential drivers of peer effects.

Peer Effects on Academic Performance

There are numerous studies looking at the effect of peers on test scores and other measures of academic performance. Most of them focus on peer effects in the classroom and typically find modest, but statistically significant effects. Studies allowing either some students to be more susceptible to peer effects or some peers to matter more typically find stronger effects. The main findings of the papers discussed in this section are summarized in Table I.

School Peers

Most of the studies investigating peer effects on academic performance focus on schoolmates. There are numerous studies looking at the effect of peer characteristics—e.g., ability, gender, immigration status, race, and socioeconomic status—on students' academic performance. These studies typically characterize peers at the classroom or at the school-cohort level and find from none to modest effects. Most of the studies that allow for heterogeneous effects find that some students are more affected by peer characteristics than others. These differences might reflect either heterogeneity in the intensity of the relationship among peers or heterogeneity in the peer effects themselves (i.e., not everyone is necessarily affected in the same way by their peers).

At the school level, Hoxby (2000) exploits idiosyncratic variation in the characteristics of peers faced by students who attend the same school in consecutive years. According to this study, an increase of one point in peers' reading scores increases a student's own score by between 0.15 and 0.4 points. The study shows that peer effects are stronger among individuals of the same race and argues that they do not always operate through ability. Indeed, having a larger share of females in the classroom improves math performance for both girls and boys. Lavy and Schlosser (2011) follows a similar approach to study peer effects in Israel. It exploits within-school variation in the share of female classmates that students encounter in elementary, middle, and high school and finds that a larger share of females in the classroom improves test scores for both genders. These academic gains seem to be driven by lower levels of classroom disruption and violence, improved inter-student and student-teacher relationships, and lessened teachers' fatigue. In contrast to the previous two studies, Black et al. (2013) finds that Norwegian male students' IQ is not affected by exposure to female classmates during high school. They also find that peers' average age, parental

education, and household earnings matter little for IQ.[2] They find, however, that peers' household earnings increase the years of education completed by male students as well as their likelihood of working full-time as adults.

There are also numerous studies investigating how the race of peers impacts academic performance. Angrist and Lang (2004), for instance, exploits variation from a desegregation program in Massachusetts—Metco—that moved students from schools in inner city areas to schools in more affluent areas. They find that the scores of not-Metco students are generally not affected by the arrival of Metco students. Metco students typically have lower test scores and are more likely to belong to a minority than their peers in the host schools. The study finds some evidence of negative peer effects on minority third-grade female students, but these negative effects fade over time, a result that the authors interpret as evidence of non-relevant peer effects. Hanushek et al. (2009) use detailed student records from Texas and try to isolate the effect of a classroom racial composition, from differences in peer ability and family background. Their findings show that while a higher percentage of black schoolmates worsens academic achievement for blacks, it does not significantly affect academic achievement for whites. Diette and Uwaifo Oyelere (2014) does not directly look at race. It focuses instead on the impact that limited English proficiency (LEP) students have on non-LEP boys and girls and on non-LEP black and white students. Similarly to previous studies, this work exploits within-school variation in exposure to LEP students in North Carolina between 1998 and 2006 and finds that while the share of LEP students in a class does not seem to affect girls, does worsen the academic performance of boys independently of their race. Figlio and Özek (2019) conduct a similar study but exploiting the large influx of poor, non-English-speaking Haitian migrants into Florida public schools that followed the devastating 2010 earthquake. In contrast to Diette and Uwaifo Oyelere (2014), they find zero or modestly positive effects of Haitian migrants on the educational outcomes of incumbent students independently of their socioeconomic status, grade level, ethnicity, or birthplace.

Peer achievement is also a dimension that has been extensively studied. As in the case of other peer characteristics, studies on peer achievement do not always coincide. Hoxby and Weingarth (2005), for instance, exploits a large number of quasi-experiments generated by school reassignments in

[2]The IQ score is only available for male students. It comes from an exam that Norwegian students take when they start military service.

the Wake County school district. They test different models of peer effects and conclude that a higher-achieving peer is better for a student's own achievement all else equal. According to their analyses, peers' race, ethnicity, income, and parental education have at most very little effect on students' performance after accounting for peers' achievement. Thus, they argue that the school reassignment policy at Wake County affected achievement through the redistribution of low- and high-achieving peers, and not through the redistribution of students by race or income. In line with the previous study, Imberman et al. (2012) find that students forced to leave their schools by Hurricanes Katrina and Rita did not affect or affected very little the average academic performance of students in receiving schools in Houston and Louisiana. They do find, however, that student achievement improves with high-achieving peers and worsens with low-achieving peers.

In contrast to the studies discussed in the previous paragraph, Abdulkadiroğlu et al. (2014) finds that peer achievement does not seem to significantly affect students' performance. They exploit quasi-random variation generated by admission cutoffs at heavily oversubscribed exam schools in Boston and New York. Despite experiencing large changes in peers' test scores and other characteristics (i.e., fewer nonwhite peers), students at the margin of gaining admission to one of these schools do not experience important changes in their own academic performance or in the quality of the college they attend. Ellison and Swanson (2016) use data from the American Mathematics Competitions to analyze the rates at which different high schools produce high-achieving math students. They try to understand what is behind the large differences they find in the production of high-achieving students across schools and conclude that the effectiveness of educational programs is not primarily driven by direct peer effects.

There are other ways in which peer achievement can impact academic performance. Murphy and Weinhardt (2020) uses data on the universe of English students and shows that independent of underlying ability, the academic rank of a student during primary school has lasting impacts on secondary school achievement. The effects are particularly strong for men. On top of affecting test scores, students' academic rank in primary education affects their confidence and subject choice.

Although not directly linked to achievement, two studies show that the previous education experience of peers impacts individuals' academic performance. Neidell and Waldfogel (2010) focuses on preschool education and finds that students starting elementary school with larger shares of stu-

dents who attended preschool perform better on math and reading. Opper (2019) focuses instead on the transition between elementary and middle school and finds that teacher quality in elementary school impact peer outcomes in middle school. Indeed, according to this paper, ignoring teacher spillovers underestimates teacher value added by 30 percent.

So far the discussion has focused on primary and secondary education. There are, however, also some studies investigating peer effects in higher education. Carrell et al. (2009), for instance, exploits quasi-random variation in the classmates that freshmen students have in their first-year courses and find considerably larger peer effects than the ones documented in previous studies. This study finds that for freshman students a 100-point increase in the peer-group average SAT verbal score increases individual GPA by nearly 0.4 grade-points on a 4.0 scale.[3]

Continuing with studies on peer effects in higher education, Bianchi (2020) exploits variation generated by a policy that expanded access to STEM majors in Italy. This study finds that giving access to these majors to less prepared students lowered the learning of incumbent students in their core courses by generating congestion of teaching resources. Interestingly, the learning of incumbent students improved in courses in which the newly admitted students were better prepared.

Booij et al. (2017) study peer effects among economics undergraduate students in the Netherlands. They randomize the allocation of students to tutorial groups generating either mixed-ability groups or ability-specific groups (i.e., tracking). This design allows them to compare within a unified setting the effects of alternative peer group configurations. They find that while high-ability students are not affected by the composition of their tutorial group, low- and medium-ability students improve their academic performance by 0.19σ when grouped with students of similar levels of ability. They do not find evidence of teachers adjusting their strategies depending on group composition, and present survey evidence indicating that low-ability students have more positive interactions with other students and are in general more engaged in the course under tracking than under mixed-ability grouping. Garlick (2018) conducts a similar study in South Africa in which some roommates are randomly assigned and some others are allocated based on ability. In this setting, tracking worsens low-scoring students' GPA and does not change high-scoring students' GPA. On the other

[3]When replicating the analyses on the effect of college roommates in Sacerdote (2001) and Foster (2006), the study finds null to moderate peer effects. Section discusses the evidence on college roommates in detail.

hand, low-scoring individuals randomly paired with high-scoring individuals improve their academic performance. These peer effects are stronger among socially proximate students and in contrast to Booij et al. (2017) indicate that student tracking is detrimental both in terms of average achievement and in terms of inequality. Note, however, that while in Booij et al. (2017) tracking is implemented at the tutorial group level, in Garlick (2018) it is implemented at the dorm room level. The intensity and nature of interactions that take place in a controlled environment—i.e., the classroom—might be quite different from the ones that take place in student dorms.

Finally, Isphording and Zölitz (2020) propose a new approach to estimate peer effects. They borrow from the teacher value-added literature and instead of focusing on specific peer characteristics, they estimate the value-added of a peer. As explained in the paper, peer value-added captures social spillovers irrespective of whether they are generated by observable or unobservable characteristics. The study exploits repeated random assignment of university students to sections and shows that there are large differences in the peer value-added of students. It also shows that high-value-added peers substitute for the lack of other learning inputs, such as good teachers. Interestingly, observable characteristics commonly used in peer effect studies—e.g., past academic performance—are poor predictors of peer value-added.

As shown in this section, peer effects on academic performance have been widely studied. Although in general peers seem to impact test scores and GPA, there are important differences across settings. Identifying which peers and which peer characteristics matter for different individuals and for different outcomes is challenging. A better understating of the mechanisms behind peer effects might shed some light on what is behind these differences.

Siblings

There are also a few studies investigating sibling spillovers on academic performance.

Qureshi (2018b) finds that in North Carolina younger siblings benefit from having an older sibling with more experienced teachers. According to this study own reading teacher experience improves children's reading test scores by 0.042σ and their younger siblings' reading test scores by 0.010σ (i.e., 25% of the main effect). This effect, however, is not symmetric. Older siblings are not affected by the quality of their younger siblings' teachers. The paper argues that this pattern is consistent

with direct sibling effects rather than with parental responses.

Nicoletti and Rabe (2019) study instead sibling spillovers in England state schools. They observe students' test scores when they are 11 and 16 years old. To estimate sibling spillovers the study relies on specifications that control for individual fixed effects and that instrument older sibling performance at age 16 with their peers' performance at age 11. Following this strategy, the study finds that a 1σ improvement on older siblings' test scores improves their younger siblings' test scores by 0.11σ.

Finally, Karbownik and Özek (2019) study sibling spillovers in Florida. Taking advantage of the discontinuities generated by school-entry cutoffs they document positive spillovers for low socioeconomic status siblings, but negative spillovers for high socioeconomic status siblings. They argue that these results are consistent with direct spillovers dominating in economically disadvantaged families and with parental reallocation of resources in more affluent families.

Sibling spillovers are typically larger than the peer effects documented within the classroom. However, there is some evidence that depending on the setting and family background the sign of spillovers could change. This is an important element to have in mind, especially when trying to incorporate this type of peer effect into cost-benefit analyses and into the design of new policies.

Neighbors

The third type of peers analyzed in this document is neighbors. There is robust evidence that exposure to a better neighborhood as a child reduces teenage pregnancy, improves future earnings, and increases the probability of college enrollment (Chetty et al., 2014, 2016; Chetty and Hendren, 2018a,b). However, from these results, it is difficult to tell to what extent neighborhood effects are driven by exposure to better peers or to better institutions (i.e., schools, health services, infrastructure, and security). The policy implications of these alternative drivers are very different. As Burdick-Will and Ludwig (2010) point out, if neighborhood effects are mainly driven by the quality of local institutions, then individuals' outcomes could be improved by investing in these institutions without having to move disadvantaged individuals to new areas.

This section discusses the evidence on the impact of neighbors on academic performance.

Goux and Maurin (2007) is one of the first studies investigating peer effects in the neighborhood. As discussed in this article, identifying neighbor effects is challenging as people living near each other typically share many other characteristics that are correlated with their performance at school (i.e., correlated effects). In addition, identifying close neighbors—the ones that presumably matter the most—is usually difficult as most datasets with geographic information define neighborhoods at a too broad level. In this paper, the authors overcome these challenges by taking advantage of some unique features of France and find that an adolescent's performance at the end of junior high school is strongly influenced by the performance of other adolescents in the neighborhood. According to this study both the date of birth of close neighbors within a year—a variable that has been shown to impact individual academic performance—and the proportion of non-educated families living in the neighborhood to which applicants to social housing are allocated significantly impact academic performance at adolescence. The measures of academic performance used in this study are grade retention and high school dropout probabilities.

Åslund et al. (2011) study instead how exposure to educated adults in the neighborhood impacts academic performance. To identify this effect, the paper exploits quasi-random variation in the location to which refugees recently arrived to Sweden are allocated. They find that a 1σ increase in the share of highly educated adults in the neighborhood sharing the same ethnicity as refugee children raises their compulsory school GPA by 0.8 percentile ranks.

Gibbons et al. (2013) investigate neighbor effects in England. To identify the effect of neighbors on academic performance, they explore what happens with children from residentially immobile families when some of their neighbors leave. In contrast to the previous two studies, they find no evidence of neighbor effects on academic performance. The early academic performance of neighbors moving to a new area does not seem to affect the academic performance of the children who remain in the neighborhood during their secondary education. In a follow-up paper, Gibbons et al. (2017)—the same authors of the previous study—investigate whether neighborhood stability matters. This study, instead of focusing on particular characteristics of the individuals leaving the neighborhood, investigates the consequences of neighborhood turnover on student outcomes. Neighborhood stability can be important as it facilitates the formation of ties and friendships, elements that are likely to impact educational outcomes. According to this study, a high turnover

of same-school-grade neighbors worsens the academic performance of the students who remain in the neighborhood. In contrast, a high turnover of neighbors in different grades does not impact individual outcomes.

Starting with the seminal work of Sacerdote (2001), a few papers exploit quasi-random variation in the allocation of college students to dorms. Sacerdote (2001) finds very local and relatively small peer effects on the GPA of undergraduate students at Dartmouth College. According to this paper, sharing a room with a peer finishing freshman year with a GPA one standard deviation higher improves own freshman-year GPA by 0.05. The academic performance of other students in the same dorm, however, does not seem to matter. Zimmerman (2003) and Foster (2006) find similar results for students at Williams College and at the University of Maryland, respectively. The former finds that college roommates' verbal SAT score has a small, but significant effect on academic performance; the latter finds that peers living in near proximity of each other have no significant effect on individuals' academic performance. Stinebrickner and Stinebrickner (2006) argues that the null to moderate effects reported by previous papers exploiting random variation in college roommates might be a consequence of focusing on a selected sample of students for whom peers are not necessarily relevant. As Sacerdote (2001) argues finding moderate peer effects among Dartmouth students is not surprising as they have already reached college age and have been heavily pre-screened for admission. The same argument can be made for students at Williams College or Maryland University as both are very selective higher education institutions. The paper by Stinebrickner and Stinebrickner (2006) studies instead peer effects among a considerably more diverse body of students—i.e., students at Berea College in central Kentucky. In this setting, they find that roommates' high school GPA and household earnings matter, especially for women. Note that despite the popularity of the college roommates research design, Angrist (2014) calls for a careful interpretation of findings that rely on this approach. The instruments that random allocation of roommates generates on peer characteristics are likely to be weak, and multiple weak instruments together with relatively small sample sizes produce estimates that are biased toward OLS.

As in the case of peer effects in the school and in the family, there is some heterogeneity in the neighbor effects documented in the literature. The differences across studies highlight the

relevance of defining peer groups correctly, identifying the relevant characteristics that matter, and understanding what is driving the documented peer effects.

Peer Effects on Educational Trajectories

There is evidence that on top of affecting test scores or GPA, peers influence our educational trajectories. This is an important margin to study. Especially in settings with high levels of segregation, causal links between the educational paths of peers likely explain persistent inequalities across different groups of students.

Peers might impact educational trajectories by transmitting relevant information, by providing support in applications and in the preparation of admission exams when required, or by shaping students' preferences. This section describes the main findings in this literature. As in Section , studies are grouped by type of peer: school peers, siblings, and neighbors. Table II summarizes the studies discussed below.

School Peers

A couple of studies investigate how peer characteristics impact individuals' trajectories. Black et al. (2013) exploits idiosyncratic variation in the characteristics of the peers to which nine grade students are exposed at school in Norway. Similarly to what Hoxby (2000) finds for test scores, they find that the share of female students in a grade improves both educational attainment and labor market outcomes for women. However, in contrast to Hoxby (2000), their results indicate that having more female classmates worsens men's outcomes: they become less likely to choose the academic track in high school and they complete fewer years of education. Being more exposed to women in grade nine also seems to worsen men's performance in the labor market, although these effects are not statistically significant. According to this study, peers' parental education and peers' household earnings do not seem to affect students' trajectories in relevant ways. Continuing with studies looking at the effect of peers' characteristics on educational and labor market trajectories, Carrell et al. (2018) exploit within school-by-grade variation in exposure to disruptive peers. In this setting, disruptive peers are defined as kids coming from families linked to domestic violence cases. This study finds that having an additional disruptive peer in a class of 25—especially if the

disruptive peer is male—reduces college enrollment, college completion, and earnings measured at age 24 to 28.

Bursztyn and Jensen (2015); Bursztyn et al. (2019) take a different angle and study how peer pressure and social norms influence individuals' educational investments. Both studies rely on randomized control trials. The first tests whether promising students to keep their participation in a SAT preparatory course secret affects take-up. The second builds on the original experiment, but varies as well the probability of actually "winning" a place in the SAT preparatory course. Through these experiments, the authors show that in settings where effort is penalized, making participation in the course observable reduces interest in it. In addition, it shows that in settings in which academic ability is valued, making students' performance observable reduces the take-up among low-ability individuals. In line with the "acting white" idea discussed in Austen-Smith and Fryer Jr (2005), these studies show that peers reinforce social norms and that peer pressure influences individual choices in relevant ways.

Peer ability can influence students' outcomes in multiple ways. Typically, it is assumed that being surrounded by high-ability peers improves students' outcomes by generating a better learning environment and by the transmission of knowledge through formal and informal interactions. Elsner et al. (2021), however, show that peer ability also matters for other reasons. Exploiting random assignment of students to teaching sections in a Business School in the Netherlands, they show that the relative rank of a student in a teaching section matters. Students with high relative rankings in their teaching sections become more likely to take follow-up courses and to major in the same topics.

A recent paper by Barrios-Fernández et al. (2022) shows that college peers can also have intergenerational effects on educational trajectories. Indeed, using a regression discontinuity design, this study shows that the college peers of Chilean parents influence the type of K-12 school and the social circles that their children join.

As in the case of test scores, there are multiple ways in which school and college peers seem to influence educational trajectories. Some of them are related to academic ability, but there are multiple other ways in which peers impact individuals' paths.

Siblings

This section summarizes the evidence on sibling spillovers on educational trajectories. It first discusses studies focusing on sibling spillovers on years of education and concludes by analyzing the evidence on sibling spillovers on the choice of educational institutions and fields of study.

A few studies document sibling spillovers in completed years of education. Qureshi (2018a) studies how older sisters' schooling impacts their younger brothers in Pakistan. Exploiting variation in distance to the nearest school for girls to instrument for sisters' schooling, they find that eldest sisters' additional schooling increases their younger brothers schooling as well. Similarly, Gurantz et al. (2020) document sibling spillovers in the probability of taking advanced placement exams in the United States. These exams are typically required to apply to college, so finding sibling spillovers in the probability of taking them suggests that there are also spillovers on completed years of education. Finally, Joensen and Nielsen (2018) exploit quasi-random variation from a school pilot scheme implemented in Denmark and show that older siblings' enrollment in advanced math and science courses during high school increases their younger siblings' propensity to take such courses. This result indicates that older siblings not only impact the amount of education, but also the type of education that younger siblings pursue.

It has also been shown that older siblings impact the educational institutions their younger siblings attend. Dustan (2018), for instance, exploits quasi-random variation generated by Mexico City's high school assignment mechanism and shows that admission to a specific high school significantly increases the probability of having a younger sibling applying and attending the same institution. Legacy enrollment is not an issue in this setting, so this finding is not a mechanical result of admission advantages to relatives of former students. Altmejd et al. (2021) investigate instead sibling spillovers in the transition between high school and higher education in Chile, Croatia, Sweden, and the United States. The study exploits quasi-random variation generated by different features of college admissions in these countries and shows that older siblings impact both the decision to enroll in college and the decision of which college to attend. Finally, Dahl et al. (2020) follows a similar approach and shows that the field in which Swedish older siblings specialize impacts the field of study that their younger siblings choose in high school.

The evidence presented in this section adds to the results discussed in Section . In addition to impacting academic performance, siblings play an important role in shaping educational trajectories. They affect the years of education that individuals complete, the education institutions they attend, and the fields in which they specialize. All these margins have shown to be very consequential both in the labor market and in other relevant life dimensions.

Neighbors

This section discusses the evidence on the impact of neighbors on educational trajectories. This is an area in which the evidence is still scarce and although it confirms the existence of relevant neighbors' spillovers, it is still needed more research studying the influence of neighbors in other settings and trying to identify its main drivers.

Bobonis and Finan (2009) study neighbors' effects on secondary school enrollment in rural communities of Mexico. They take advantage of the random allocation of a conditional cash transfer program—*Progresa*—to some rural communities. *Progresa* consisted of a cash transfer to families conditional on sending their children to primary and secondary school. Not all the members of the community were eligible to participate in this program. In order to qualify, families need to score below a welfare threshold. The authors take advantage of this feature of the program to study spillovers of eligible to non-eligible families. They find that *Progresa* increases enrollment in secondary education for both, the children of eligible families—i.e., those eligible for the cash transfer—and for the children of non-eligible families. This last finding indicates the presence of neighbor spillovers in the decision to attend secondary education.

Barrios-Fernández (2022) documents similar neighbor effects, but in the decision to enroll in college. This study exploits variation generated by the rules that determine eligibility for student loans in Chile and shows that high school seniors are significantly more likely to attend and complete university when their closest neighbor—defined as the closest individual applying to university one year before they reach the senior year in high school—becomes eligible for a student loan and enrolls in university. This increase in enrollment is mediated by an increase in the probability of taking the admission exam and applying to university.

Michelman et al. (2022) study peer effects at the college level by exploiting random allocation of students to dorms in the Harvard of the 1920s and 1930s. They find that while high-status individuals do benefit from interacting with high-status peers—i.e., they become more likely to join exclusive clubs and to have successful careers in finance–low- and mid-status individuals do not. This paper highlights that peer effects do not necessarily affect educational trajectories for academic reasons. Indeed, the peer effects documented in this study are more linked to social than to academic dimensions. In line with these findings, Sacerdote (2001) finds that college roommates and dormmates at Dartmouth College impact the probability of joining fraternities.

As schoolmates and siblings, neighbors seem to influence educational and life trajectories in important ways. However, further research is still needed to gain a better understanding of the mechanisms behind these peer effects.

Peer Effects on Other Outcomes

The previous two sections focus on peer effects on academic performance and educational trajectories. However, school peers, siblings, and neighbors likely influence many other relevant outcomes. This section discusses some of the evidence on peer effects in outcomes that although not directly related to educational achievement arise in educational contexts or are likely to impact educational trajectories (i.e., affect students in school age). Thus, there are many studies on peer effects that might be excluded from this section, especially in the case of siblings and neighbors.

School Peers

There has been vast interest in understanding how school and college peers influence non-educational outcomes. Gaviria and Raphael (2001) is perhaps the study that looks at the largest set of non-educational outcomes: drug use, alcohol drinking, cigarette smoking, churchgoing, and dropping out of school. It uses a sample of tenth-graders drawn from the National Education Longitudinal Survey (NELS) in the United States and finds evidence of strong school-level peer effects on all five outcomes. However, for two of them—i.e., drug use and alcohol drinking—the study cannot completely rule out peer effects being driven by selection bias.

Other studies investigate instead peer effects on misconduct within the school. Bennett and

Bergman (2021), for instance, uses administrative data from West Virginia and develops a new approach to identify social networks based on students who are truant together. It validates the approach by showing that a parent information intervention on absences has spillovers on the peers of treated students. These spillovers are non-negligible. Indeed, according to the study ignoring them underestimates the cost-effectiveness of the program by 43%. Imberman et al. (2012) also finds evidence of peer effects on truancy. This study finds that despite not affecting academic performance, evacuees from Hurricane Rita increased absenteeism and disciplinary problems among incumbent students of the Houston schools that received them. As Bennett and Bergman (2021), Avvisati et al. (2014) find that an intervention designed to improve parental involvement in disadvantaged French middle schools improves children's behavior at school—especially in terms of truancy and disciplinary sanctions—and that it is amplified at the class level by peer interactions. Continuing with studies on peer effects on school misconduct, Carrell et al. (2008) investigates peer effects on cheating in the three major United States military service academies—i.e., Air Force, Army, and Navy. It relies on self-reported data on academic cheating between 1959 and 2002 and finds that higher levels of cheating among peers increase students' own probability of cheating. According to this study, an additional college peer who cheated in high school increases cheating by 0.33 to 0.47 additional students, while an additional college peer who cheated in college increases cheating by 0.61 to 0.75 additional students.

On a more dramatic margin, there is also evidence that school peers can influence participation in crime. Deming (2011) studies the effect of the middle and high school attended on adult crime. The study exploits variation generated by lotteries used to assign students to schools in the Charlotte-Mecklenburg school district and finds that seven years after the assignment lottery winners have been arrested for fewer serious crimes and have spent less time in prison. The study presents suggestive evidence that while in middle school peer influence is an important driver of the effect, in high school the main driver is school quality. Similarly, Eren et al. (2022) exploits grade retention cutoffs for eighth graders in Louisiana and finds that grade retention increases the likelihood of violent crime conviction by 1.05 percentage points (58.44%). As in Deming (2011), peers seem to play an important role in explaining these findings.

The studies discussed in this section show that school peers influence many important outcomes

on top of academic performance and educational trajectories. From a policy perspective, this is something important to have in mind. There might be important trade-offs when trying to modify a class composition, as trying to maximize an outcome could worsen others.

Siblings

There are multiple studies documenting high correlations in risky behavior between siblings, suggesting that siblings might influence each other actions. However, identifying whether there is a causal component behind these correlations is challenging. Altonji et al. (2017) take up this challenge and investigate whether sibling correlations in substance use and drug selling are explained at least in part by a causal effect. Relying on some assumptions about the direction of the influences, they calibrate a dynamic model and conclude that although smoking, drinking, and marijuana use seem to be influenced by the example set by older siblings, most of the correlations observed between siblings come from common influences (i.e., correlated effects).

Closer to the evidence discussed in Section , Bingley et al. (2021) document sibling spillovers in occupational choice in Denmark. They find that the random assignment of an older brother to serve in the military increases younger brothers' probability of also serving in the military by 7%. They document considerably larger effects for closely spaced sibling pairs without sisters in the family.

There are other shocks to siblings' lives that can also generate spillovers within the family. Heissel (2017), for instance, shows that siblings of teen mothers worsen their performance at school, and become more likely to drop out from high school and to interact with the juvenile justice system following the birth of their niece/nephew. The drivers of these sibling spillovers, however, are likely very different from the ones behind the results of Altonji et al. (2017) and Bingley et al. (2021). After all, the birth of a new child generates additional demand for resources and parental support that might explain the negative sibling spillovers documented in this study.

Neighbors

There are well-documented neighborhood effects on crime and delinquency. Kling et al. (2005), for instance, study the effects of the Moving to Opportunity (MTO) initiative on juvenile crime and

delinquency. MTO randomly assigned housing vouchers that families could use to move to better neighborhoods in five US cities. The study shows that relocating to lower-poverty areas reduces arrests for property and violent crime among young women. It also reduces violent crime among young men, but increases their participation in property crime. As in the case of other studies on neighborhood effects, from this evidence, it is difficult to distinguish between the role of neighbors and the role of neighborhood institutions.

Billings et al. (2019) address this challenge and document relevant social spillovers on crime. They exploit random variation in neighborhood residence along opposite sides of a newly drawn school boundary and show that neighborhood and school segregation increase crime by fostering social interactions between at-risk youth. The study first shows that grouping more disadvantaged students in the same school increases total crime. In addition, it shows that these disadvantaged students are more likely to become "partners in crime"and commit crimes together.

Neighbors are likely to also impact other margins. The Opportunity Insights team has produced vast evidence on neighborhood effects in the US and it is an excellent starting point to have a more comprehensive view of the margins that neighbors might impact.

A recent study by Lucia Corno and Burns (2022) exploits random allocation of college roommates in South Africa and shows that being allocated to an interracial room reduces prejudices and improves attitudes from white to black students. According to the study, it also increases the likelihood of interracial friendships.

Discussion

The evidence discussed in this article indicates that there are many margins in which peers influence students' outcomes. Confirming the existence of peer effects is important as they affect the cost-benefit analyses of policies and could be incorporated into the design of new programs to maximize their impact. In the context of education, they can also help to explain persistence in inequality across social groups. Making general policy recommendations, however, is not easy. Carrell et al. (2013) illustrates the challenges of bringing results on peer effects into practice. This study tried to maximize the performance of the lowest-ability freshmen students of the US Air Force Academy. To achieve this goal, the study uses a squadron formation algorithm that relies on estimates of non-

linear peer effects obtained from previous cohorts of students randomly allocated to squadrons. The intervention, however, did not achieve its goal and worsened the performance of low-ability students who instead of interacting with their high-ability peers formed more homogeneous subgroups.

In addition, and as discussed earlier in this article, the size of the peer effects documented in the literature varies substantially across settings and depending on how peers are defined and characterized. Understanding what is behind this heterogeneity is key for extracting more general policy lessons and having a more comprehensive view of the nature and relevance of social interactions in educational contexts.

A first step in this direction consists in identifying the mechanisms behind peer effects. Although there has been some progress in this area, still further research is required to have a more comprehensive view of their drivers in different contexts. For instance, the positive effects on test scores associated with having larger shares of female classmates have often been attributed to an improved learning environment (i.e., fewer class disruptions, better relationships among students and between students and teachers, and less fatigued teachers). This hypothesis is consistent with other evidence showing that having peers who attended preschool and who behave better in elementary school improves test scores, and with evidence showing that having more disruptive peers coming from households with a domestic violence history worsens them. If a better class environment is indeed the main mechanism behind these peer effects, then this could help to understand why in some settings a larger share of female classmates does not seem to matter. Thus, the null effects documented by Black et al. (2013) in Norway could just be a consequence of Norwegian schools offering a good learning environment to start with.

When looking at other peer characteristics such as race, immigrant status, or academic achievement there are similar levels of heterogeneity, but less evidence of the mechanisms behind them. Changes in the learning environment could also be part of the story, but they are likely other drivers behind these effects. It has been shown, for instance, that peers can impact educational outcomes by reinforcing prevalent social norms. If there are social norms specific to some groups, this could explain differences in the responses to changes in classroom composition among different groups of students. For instance, the finding of Hanushek et al. (2009) that larger shares of black students worsen academic performance for other black students but not for whites is consistent with the

"acting white" idea discussed in Austen-Smith and Fryer Jr (2005). As discussed in Bursztyn and Jensen (2015) and Bursztyn et al. (2019), the sign and size of peer effects can substantially vary depending on the prevalent social norms in the reference group of a student. Therefore, differences in the reference peer groups could explain some of the heterogeneity in the size of peer effects across student groups.

There are also other reasons why peers could differentially impact students' outcomes. High-achieving peers for instance could improve the learning environment by generating fewer disruptions and by supporting other students with their learning, but at the same time, they could make it more difficult for lower-performing students to ask questions and actively participate in the class. There is evidence supporting both mechanisms and it is not clear what makes one mechanism more relevant than the other in different settings. The relative rank of a student in the classroom has also been shown to impact self-confidence and future performance. Thus, being surrounded by high-achieving peers could either improve or worsen educational outcomes.

On top of helping to rationalize differences in peer effects across settings, understanding the mechanisms behind them is important from a policy perspective. If an improved learning environment is an important driver of peer effects, then it would make sense to allocate students to class groups trying to minimize class disruptions and maximize positive interactions. But, as an alternative, it may be possible to generate better learning environments by modifying school culture or by reducing class sizes. Thus, understanding the mechanisms behind peer effects is key to know which are the alternative or complementary policies that could be used to improve students' outcomes.

Given the role played by peers in reinforcing social norms, from a policy perspective it is important not only to identify the prevalent social norms but also to understand whether and how they can be modified. Mixing students with different social norms might help to break some inertia, but educational institutions could also make directed efforts to promote certain values and social norms that are beneficial for their students. Deciding which social norms to promote, however, is challenging. As discussed in Bursztyn et al. (2019), environments that punish effort are unlikely to bring out the best of students, but environments that reward academic achievement can also be detrimental for some students.

The vast evidence documenting peer effects on educational trajectories has not been successful in assessing the relevance of the different mechanisms that could drive its findings: information transmission, direct academic support, and changes in preferences (e.g., changes in aspirations and motivation, taste for spending time with peers). Assessing the relevance of these different mechanisms is important to understand which policy tools governments have available to support students. For instance, if the main driver of peer effects on educational trajectories is the transmission of information, then governments could design strategies to substitute for the lack of informed peers and directly provide information to students.[4] However, designing effective information interventions is not trivial.[5] It is important to know what information to transmit and how to transmit it. Nguyen (2008) shows that individuals process information differently depending on the messenger, so it is not clear which is the best way of reaching potential beneficiaries.

Independently of the mechanisms behind peer effects, the existence of social spillovers on educational trajectories is relevant to understand inequality in educational achievement. They imply that the consequences of the barriers and challenges disproportionately affecting certain groups of students are amplified through their social networks. From a more optimistic perspective, these social spillovers imply that programs designed to expand access to educational opportunities among disadvantaged students and other under-represented groups likely have larger effects than those typically measured in studies that ignore their effects on the wider social network of directly treated students (see Bennett and Bergman (2021) or Avvisati et al. (2014) for examples of papers documenting multiplier effects of interventions). Investigating in which contexts these multiplier effects are more likely to arise and how they could be incorporated in the design of new policies is a promising area for future research.

Access to more and better data on social networks should facilitate identifying who are the relevant peers in different contexts and which characteristics of them matter the most. In addition, understanding whether certain nodes of social networks are more likely to generate social spillovers is also

[4] Although information transmission is likely to explain a part of peer effects, it is not the whole story. Altmejd et al. (2021) shows that sibling spillovers arise among siblings from low and highly-educated households. In addition, sibling influence pushes a similar amount of individuals to better and worse college major combinations, suggesting that peer influence goes beyond pure information.

[5] There is a vast literature studying the effect of information interventions on student outcomes. With a few exceptions—see for instance Dynarski et al. (2021), low-touch interventions have not been very successful in improving students' trajectories.

important, as it would make sense to make special efforts to reach them and to take advantage of their potential to amplify the effect of different policies. There are promising research opportunities in combining applied work with recent developments in network theory (see for instance Banerjee et al. (2019)).

Conclusion

Peer effects in education have been extensively studied. As a result, important advances have been made in finding credible strategies to overcome the fundamental identification challenges that arise in the context of peer effects (i.e., correlated effects and the reflection problem). The evidence accumulated in the last decades indicates that peers can impact both academic performance and educational trajectories in important ways.

This result is important from a policy perspective. The existence of peer effects likely affects the cost-benefit analysis of many educational policies and is a factor that could be incorporated into the design of new policies. Indeed, peer effects could be exploited to amplify the impact of educational programs. Peer effects can also help us to understand persistence in inequality in educational trajectories across different social groups.

Making general policy recommendations, however, is not easy. As discussed in this article, the size of the peer effects documented in the literature varies substantially across settings and depending on how peers are defined and characterized. Understanding what is behind this heterogeneity is thus key for extracting more general policy lessons.

The availability of more and better data characterizing the members of a social group offers promising research opportunities. This should allow us to advance in identifying which peer characteristics matter the most in different contexts and for different outcomes. In addition, advances made in the modeling of social networks and access to more granular data on social networks should facilitate identifying relevant peers and the actual reference groups of individuals.

Finally, in addition to studies documenting the existence of peer effects, more research focusing on the mechanisms behind them is needed. A better understanding of the drivers of peer effects is key for both the design of policies and for understanding the nature and relevance of different types of

social interactions among the youth.

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Table I: Peer Effects on Academic Performance

Author(s)	Context	Grade/age	Identification	Change in peers	Peer group	Outcome(s)	Findings
			Panel A: Classmates				
Hoxby (2000)	Texas	3rd to 6th grade	Within-school variation in peer characteristics across cohorts (gender/race)	Proportion of female, native American, black, Asian, and Hispanic students in a class	Classmates	Test scores (reading and math)	Increase in female share improves test scores for all grades, except 4th grade. Increase in the share of black students decreases test scores in 3rd grade
Angrist and Lang (2004)	Brookline	3rd, 5th, and 7th grade	Variation in peers characteristics induced by Metco (desegregation program that allowed inner-city students—mostly black—to attend school in more affluent suburban districts)	Proportion of Metco students, and proportion of female and male Metco students in the classroom.	Non-Metco students	Core, math, language, and reading test scores	No impact of Metco students on the scores of white non-Metco students. Small negative impact of Metco shares on the reading and language scores of black 3rd graders.
Hoxby and Weingarth (2005)	North Carolina	3rd to 8th grade	Variation in peer-group induced by a desegregation program that reallocated students to schools to balance income composition	Avg. of previous year test scores of new peers; share of new peers in different deciles of the test scores distribution	Classmate	Total (reading plus math) score	Increase in the share of peers scoring at the top of the test score distribution the previous year improves current academic performance.
Whitmore (Whitmore)	Tennessee	Kindergarten and 1st to 3rd grade	Variation in peers characteristics (gender) induced by a random assignment of students to small or regular size class, with or without a full-time teacher's aid	Proportion of female students in the class ¿ 50%	Classmate	Percentile rank of math and reading scores	Improvement in performance for students in kindergarten and 2nd-grade. Worsening in performance for male students in 3rd-grade.
Ammermueller and Pischke (2006)	Germany, France, Iceland, Netherlands, Norway, and Sweden	Fourth graders	Variation in peer characteristics (family background) benefiting from close-to-random formation of classes with respect to family background characteristics	Index of number of books at home (1 is the lowest category (0 –10) and 5 is the highest category ($>$ 200))	Classmates	Reading test scores	Increase in test scores across the six countries, but important differences in the magnitude of the effect across countries

(Continuation of Table I)

Carrell et al. (2009)	United States	Freshman students of the Air Force Academy	Variation in peer characteristics (academic performance) induced by random allocation of students to different peer groups (i.e., roommates, squadrons, upperclassmen within the squadron)	Changes in peers' characteristics observed before the entrance to the Air Force Academy (SAT scores, academic composite).	Roommates, members of the same squadron, members of the same upper classes within the squadron.	GPA in the freshman fall semester	Average verbal SAT score of squadron peers and of upperclassmen from the squadron increases first semester GPA.
Hanushek et al. (2009)	Texas	5th to 7th grade	Within school variation in peers characteristics across cohorts (racial composition)	Proportion of black students in the grade	Classmates	Test score (math)	Decrease in test scores of black students; zero or slightly positive effect for white students depending on model specification.
Neidell and Waldfogel (2010)	United States	Kindergarten and early grades of elementary school	Within school variation in peers characteristics (enrollment in preschool)	Share of peers who attended preschool	Classmates	Test scores (math and reading)	Increase in test scores in both subjects.
Duflo et al. (2011b)	Kenya	Primary schools	Variation in peers characteristics (peer achievement) induced by random allocation of students to "tracking" and "non-tracking" schools	Peer achievement (test scores before allocation to "tracking" and "non-tracking" schools)	Classmates	Math and language test scores administered 18/12 months after the start/end of the program	Increase in test scores for students assigned to "tracking" schools.
Lavy and Schlosser (2011)	Israel	Elementary, middle and high school	Within school variation in peer characteristics (gender)	Proportion of female students in the class	Classmate	Matriculation exam score (math, science, Hebrew, and English)	Increase in math, and science test scores for girls in 5th grade, and on math and English test scores for girls in 8th grade. Increase in science test scores for boys in 5th grade.

(Continuation of Table I)

Imberman et al. (2012)	Houston, Louisiana	Elementary, middle and high school students	Variation in peers group induced by Hurricanes Katrina and Rita	Proportion of evacuees in the class	Incumbent students	Math and English test scores	No significant or small average effects of evacuees on incumbent students' test scores. Low-achieving peers worsen test scores, while high-achieving peers improve them.
Black et al. (2013)	Norway	9th grade male students	Within school across cohorts variation in peer characteristics (gender, age, socioeconomic status)	Proportion of female students in the class, average age, mother's education, and father's earnings of classmates.	Male classmates at around 18 years old	IQ Scores	No effect on IQ
Carrell et al. (2013)	Florida	3rd to 10th grade	Within school across cohorts variation in peer characteristics (disruptive peers)	Proportion of children, and of male and female students from families linked to domestic violence	Elementary school classmates	Test score	Increase in disruptive peers and in male disruptive peers worsens test scores in 3rd to 5th grade, in 9th, and in 10th grade
Abdulkadiroğlu et al. (2014)	Boston and New York	7th and 9th grade	Variation in peers characteristics (achievement and gender) induced by eligibility for exam schools	Peers' test scores the year following admissions; proportion of non-white students	Classmate	Test scores in math and English; SAT and PSAT scores	No significant effects.
Diette and Uwaifo Oyelere (2014)	North Carolina	3rd to 8th grade	Within school across cohorts variation in peer characteristics (limited English (LEP) students)	Proportion of LEP students in the grade	Non-LEP students	Math and English grades	Decrease in math grades for white males students and in reading grades for black males students
Bursztyn and Jensen (2015)	Los Ángeles	High school	Variation in peer pressure generated by RCT making participation in an SAT course observable	No change in peers, but a change in whether they observe classmates participation in the SAT course.	Classmates	Performance on an SAT preparation course	Decrease in performance at the end of the course for all students, except the ones scoring in the top 25% of the class in a baseline exam. For this group of students, performance improved.
Booij et al. (2017)	Netherlands	Undergraduate students majoring in economics	Variation in peers characteristics (peer ability) induced by a random assignment of peers to "mixed" or "tracking" tutorial groups	Peer ability (mix of ability levels in mixed groups; one ability level in tracking groups)	Tutorial group classmates	Student GPA	Increase in GPA for low- and mid-ability students allocated to tutorial groups with similar ability peers (tracking)

(Continuation of Table I)

Carrell et al. (2018)	Florida	3rd to 10th grade	Within school across cohorts variation in peer characteristics (disruptive peers)	Proportion of children, and of male and female students from families linked to domestic violence	Elementary school classmates	Test score	Increase in disruptive peers and in male disruptive peers worsens test scores in 3rd to 5th grade, in 9th, and in 10th grade
Figlio and Özek (2019)	Florida	Students enrolled in public schools between 2002-2003 and 2011-2012	Variation in peers group induced by the 2010 Haiti earthquake.	Share of Haitian refugees in the class	Incumbent students	Test scores (math, reading) and an index of performance	No effect on incumbent students regardless of their socioeconomic status, grade, or birthplace.
Bianchi (2020)	Italy	Undergraduate students majoring in STEM	Variation in peer characteristics induced by a policy that expanded access to STEM majors to graduates of vocational track high schools	Academic readiness and pre-college peer preparation for specific subjects	Incumbent students (i.e., graduates from academic track high schools)	Subject-specific GPA	Vocational-track students lowered the grades of incumbent students in courses for which they were less prepared, and increased their grades in courses in which they were better prepared
Opper (2019)	New York	Middle school	Variation in peer characteristics (peers' elementary school teacher quality) induced by the transition from elementary to middle school	Average value-added of the teachers that current peers had in elementary school	Classmates	Test scores in math and English	Peers exposed to higher value-added teachers in elementary school increase test scores in all subjects for students with whom they share race and gender.
Murphy and Weinhardt (2020)	England	Primary and secondary school	Variation in relative rank during primary education generated by within school-subject-cohort variation in test scores distribution within a class	Ability distribution generating changes in relative academic ranks in primary school	Classmates	Test scores in national KS3 examination (Math, science, and English)	Higher relative rank in primary school increases test scores in secondary education
			Panel B: Siblings				
Qureshi (2018b)	North Carolina	Siblings between 4th and 8th grade	Variation in older siblings characteristic (older sibling's teacher quality)	Years of experience of older sibling's teacher	Siblings	Reading and math test scores	Younger siblings' math and reading test scores improve with older siblings' teacher experience

(Continuation of Table I)

Nicoletti and Rabe (2019)	England	Siblings between 11 and 16 years old	IV strategy exploiting variation in siblings' academic achievement explained by older (younger) siblings' peer performance in specific subjects	Test scores of an older (younger) sibling at 16 years old	Younger (older) siblings at the same age as their siblings	Test scores in a national exam	Increase in test scores for younger siblings from less affluent families.
Karbownik and Özek (2019)	Florida	Children between 3rd and 8th grade	Variation in sibling kindergarten attendance induced by date of birth and age school-entry cutoff.	Older sibling kindergarten attendance	Siblings	Test scores (average between math and reading)	Increase/decrease in test scores for younger siblings from less/more affluent families.
			Panel C: Neighbors				
Sacerdote (2001)	New Hampshire	Freshman year roommates and dorm-mates in Dartmouth college	Variation in peers' characteristics (academic performance) induced by a random allocation of roommates and dorms	Roommates' average freshman GPA	Roommates	Student GPA	A higher roommates' average freshman year GPA increases students' GPA
Zimmerman (2003)	Massachusetts	Undergraduate students at William college	Variation in peer characteristics (peer ability) induced by a random allocation of college roommates	Roommate SAT scores	Roommates	GPA of the first semester and cumulative GPA	Students GPA increases with verbal SAT scores of roommates. Roommates in the bottom 15% of the verbal SAT distribution decrease GPA of students in the middle of the SAT distribution
Foster (2006)	Washington D.C.	Undergraduate students from the University of Maryland	Variation in peer characteristics (achievement) induced by random assignment of students to specific floors within college dorms.	Peers' average and median SAT and high school GPA	Floor-mates	GPA in the current semester	Higher median in peers' high school GPA slightly increases GPA for second-year men without other close peers in the same floor
Stinebrickner and Stinebrickner (2006)	Kentucky	College freshmen roommates at Berea college	Variation in peers characteristics (academic performance and income) induced by random allocation of college roommates	Roommate family income/10,000, high school GPA, and ACT scores	College roommates	First semester GPA	Increases in peer family income or HS GPA increase the first semester GPA for female students

(Continuation of Table I)

Åslund et al. (2011)	Sweden	Refugees under 16 years old at immigration time	Variation in neighbors' characteristics (size and education of adults from the same ethnic group) induced by a refugee residential placement policy. Neighborhood defined by SAMS (Small Area Market Statistics)	Size of ethnic and immigrant communities, share of adults with at least three years of upper-secondary education, and share of same ethnic group adults with at least three years of upper-secondary education	Refugees in school age	GPA	Share of same-ethnic group educated adults and the size of the refugees' ethnic community in the neighborhood increases students' GPA
Gibbons et al. (2013)	England	Students between 11 and 14 years old	Variation in neighborhood composition due to residential migration of other students. Neighbors are defined as students living in the same census output areas (OA) and attending the same or an adjacent school	Neighbours' characteristics (average KS1, share of students eligible for free school meals, share of students with special education needs, and share of males)	Residential immobile students	KS2 and KS3 scores	No effect on KS2 or KS3 scores
Gibbons et al. (2017)	England	High school students between 11 and 14 years old	Within secondary school variation in residential peers turnover ("movers"). A neighborhood is defined by census output areas	Annual turnover (share of "movers" in the neighborhood)	Students in the same grade as the "movers" that stay ("stayers")	Test scores (KS3-KS2)	Higher levels of same-grade student turnover decrease test scores among the students who remain in the neighborhood
Garlick (2018)	South Africa	Roommates	Variation in peer characteristics (peer ability) induced by two residential group assignment policies (Random allocation of dormitories and tracking allocation based on prior academic performance)	Dormitory high school graduation test score	Roommates	Student GPA	Low-scoring students randomly assigned to high-scoring peers increase their GPA. When assigned to other low-scoring peers their GPA decreases

Notes: This table summarizes the findings of papers studying peer effects on academic performance at different educational levels. Panel A focuses on studies looking at classmates, Panel B on studies looking at siblings, and Panel C on studies looking at neighbors.

Table II: Peer Effects on Educational Trajectories

Author(s)	Context	Grade/age	Identification	Change in peers	Peer group	Outcome(s)	Findings
				Panel A: Classmates			
Gould et al. (2009)	Israel	High school	Variation on peer characteristics (immigrants) induced by a migration wave from the Soviet Union to Israel in the early 1990s	Proportion of immigrant students in 5th grade	Incumbent classmates	Dropout probability and passing the high school exit exam (necessary to attend college)	An increase in the proportion of immigrant students decreases the passing rate of native students.
Carrell and Hoekstra (2010)	Florida	3rd to 10th grade	Within school-by-grade variation in peers characteristics (disruptive peers)	Proportion of children/males/females from families linked to domestic violence in elementary school	Classmates	College enrollment, college graduation, four-year college degree	An increase in the proportion of disruptive boys—i.e., boys from families linked to domestic violence cases—decreases college enrollment and the probability of receiving any degree.
Black et al. (2013)	Norway	9th grade male students	Within school variation in peer characteristics (gender/age/socioeconomic status)	Proportion of female students, average age, average mothers' education, and fathers' earnings in the class.	Classmates	School track, dropout, completed years of education, and full-time work	An increase in the share of female students in the class decreases the probability of enrolling in the academic track and the years of education for boys. It increases the probability of working full-time for girls. An increase in the earnings of peers' fathers, increases completed years of education and the probability of working full-time for boys. Higher levels of education among peers' mothers increase completed years of education for girls.
Bursztyn and Jensen (2015)	Los Ángeles	High school	Variation in peer pressure generated by RCT making participation in an SAT course observable	No change in peers, but a change in whether they observe classmates participation in the SAT course.	Classmates	Sign up for an online SAT preparatory course	Making participation public decreases sign-up probabilities in non-honor classes, and increases participation in honor classes.

(Continuation of Table II)

Booij et al. (2017)	Netherlands	Undergraduate students majoring in economics	Variation in peer characteristics (peer ability) induced by a random assignment of peers to "mixed" or "tracking" tutorial groups	Peer ability (mix of ability levels in mixed groups; one ability level in tracking groups)	Tutorial group classmates	Dropout rates	Decrease in dropout rates for low- and medium-ability students assigned to a three-way tracking group.
Bursztyn et al. (2019)	Los Ángeles	High school	Variation in peer pressure generated by RCT making performance and participation in an SAT course observable	No change in peers, but a change in whether they observe performance and participation in SAT course	Classmates	Sign-up for online SAT preparatory course	Making the decision public reduces participation for all students regardless of the type of school. In "Smart to be cool" schools (i.e., those that penalize effort) sign-up rates were higher when the probability of actually getting a place in the course was high. In "Cool to be smart" schools (i.e., those that value academic ability) participation was higher when the probability of actually getting a place in the course was low.
Elsner et al. (2021)	Netherlands	Business school undergraduate students	Variation in peer characteristics (peer achievement) induced by random assignment of students into sections within courses	Ordinal rank for a given GPA level	Business school classmates	Course dropout, passed course, taking follow up course, number of follow up courses, graduation in related major, taking math electives, and college graduation	A higher rank reduces the probability of dropping the course, and increases the probability of passing the course, taking a follow-up course, graduating in a related subject major, and choosing electives with a higher math intensity. It also increases the number of follow-up courses

(Continuation of Table II)

Panel B: Siblings

Goodman et al. (2015)	United States	Students in the transition between high school and college	Descriptive associations on siblings' higher education trajectories controlling by high school and college application year	Older sibling's academic performance (high school GPA and SAT scores); characteristics of college attended by older siblings (2-year or 4-year college, selectivity).	Younger siblings	Probability of enrolling in a 4-year college or in a highly selective college. Probability of applying and enrolling in the same type (2-year/4-year) or in the same college as the older sibling.	Younger siblings' probabilities of following the older sibling's path increase with the older sibling's academic performance.
Dustan (2018)	Mexico City	Students in the transition between primary education and high school	Variation in older sibling high school induced by a centralized admission mechanism	High school of older sibling	Younger siblings	Probability of applying (listing it in the first or in any preference) and being assigned to the target high school of the older sibling	Younger siblings are more likely to apply and be assigned to a high school if an older sibling was admitted before.
Joensen and Nielsen (2018)	Denmark	High school students	Pilot-program induced variation in older siblings' probability of taking advanced courses in math and science	Older siblings taking/not taking advanced costs in math and science	Younger sibling	Probability of taking advanced math and science courses	Increase in younger siblings' probability of taking advanced math and science courses when an older sibling less than four years apart takes them.
Qureshi (2018a)	Pakistan	School-age students	IV exploiting variation in older sisters' schooling generated by distance to the closest girls' school	Older sister schooling	Younger brothers	Being capable to read, write, add, count and completed schooling	Older sister schooling improves all the outcomes.
Dustan (2018)	Mexico City	Students in the transition between primary education and high school	Variation in older sibling high school induced by a centralized admission mechanism	High school of older sibling	Younger siblings	Probability of applying (listing it in the first or in any preference) and being assigned to the target high school of the older sibling	Younger siblings are more likely to apply and be assigned to a high school if an older sibling was admitted before

(Continuation of Table II)

Gurantz et al. (2020)	United States	High school students	Variation in older brothers' integer scores (1-5) in advanced placement exams generated by thresholds in the continuous scores behind them.	Older sibling score on advanced placement exam	Younger siblings	Probability of taking the same advanced placement exam, total of advanced placement exams.	A higher older sibling's integer score in an advanced placement exam increases the probability that younger siblings take the same exam. It also increases the number of advanced placement exams taken.
Altmejd et al. (2021)	Chile, Croatia, Sweden, and the United States	Students in the transition between high school and higher education	Variation in older siblings' higher education trajectory induced by college admissions cutoff	Older sibling marginally admitted to specific colleges or college-major combinations	Younger siblings	Probability of applying and enrolling in older siblings' target college, college-major combination, and major	Younger siblings more likely to apply and enroll in a college and in a college-major combination if an older sibling was admitted there in the past.
				Panel C: Neighbors			
Sacerdote (2001)	New Hampshire	Freshman year roommates and dorm-mates in Dartmouth college	Variation in peer characteristics induced by a random allocation of college roommates and dormmates.	Roommates/dormmates membership to fraternity/sorority/coed; roommates/dormmates drinking habits in high school	Roommates and dormmates	Joins a fraternity/sorority or becomes a varsity athlete	A larger share of dormmates joining a fraternity/sorority/coed or consuming beer in high school increases the probability of joining a fraternity.
Goux and Maurin (2007)	France	Adolescents (15 to 16 years old)	Within neighborhood variation in peers characteristics (date of birth, family background) induced by random assignment of families to public housing	Proportion of neighbors born at the beginning or at the end of the year (generate differences in school starting age), proportion of neighbors who have been held a grade, and proportion of neighbors who did not complete high school	Adolescents at the end of junior HS	Probability of being held back or repeating a grade	The probability of being held back increases with a higher proportion of high school dropouts in the neighborhood and a higher proportion of neighbors that were held back at the age of 15. Also, this probability decreases with a higher proportion of neighbors who were born at the beginning of the year (Jan-May).

(Continuation of Table II)

Bobonis and Finan (2009)	Rural communities in Mexico	Students in the transition between primary and secondary school	Variation in neighbors' school attendance induced by a conditional cash transfer program—i.e., PROGRESA—randomly introduced in some rural communities. The transfer is conditional on sending children to school	Neighbors' enrollment rate in secondary school	Non-eligible children residing in communities in which PROGRESA was implemented	Probability of enrolling in secondary school	Having more neighbors enrolled in secondary education increase neighbors non-eligible for PROGRESA enrollment in secondary education as well.
Barrios-Fernández (2022)	Chile	Students in the transition between high school and higher education	Variation in close neighbors' university attendance induced by eligibility for student loans (sharp cutoff based on college admission exam)	Closest neighbor eligible/not eligible for a student loan	Individuals who could apply to college one year after their close neighbors	Probability of applying to and enrolling in university; probability of completing a university degree	Increase in applications, enrollment and graduation from 4-year colleges when a close neighbor becomes eligible for a student loan and enrolls in university.
Michelman et al. (2022)	Massachusetts	Undergraduate students from Harvard University during the 1920s and 1930s	Variation in exposure to high-status peers induced by random assignment of college roommates	Residential peers' social status	College students living in the same residential neighborhood	Major and occupational choice; membership to prestigious professional associations	High-status college peers push high-status students to participate more in extracurricular activities and join selective final clubs. Also, 25 years after graduation, adults that went to private feeders schools and were assigned to high-status college peers, participate more in prestigious social organizations. The interaction with high-status college peers pushes high-status students to follow careers with higher shares of private feeder students as finance, and for low- and mid-ses students it induced them to do the opposite.

Notes: This table summarizes the findings of papers studying peer effects on educational trajectories at different educational levels. Panel A focuses on studies looking at classmates, Panel B on studies looking at siblings, and Panel C on studies looking at neighbors.