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Understanding spillover of peer parental education: Randomization evidence and mechanisms *

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Abstract

We utilize random assignment of students into classrooms in China middle schools to study the mechanisms behind the spillover of peer parental education on student achievement. Analyzing the China Education Panel Survey, we find a causal relationship between classmates' maternal education and student test score. In addition to the conventional peer effect and teacher response channel, we identify mother adjustment of parenting style as another important mediating factor. We provide suggestive evidence about the existence of mother's network, which facilitates the change in parenting style. We also find that the spillover of peer maternal education on non-repeaters and non-migrant students is stronger, primarily driven by higher parental investment on time.

Keywords: peer effect, peer parent, parental investment, parenting style

JEL Classification: D91, I24, J13, Z13

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1 Introduction

Parental characteristics of peers are often treated as the endowment of peers in the peer effect literature. For example, parental education is used to proxy for peer quality to estimate spillover on achievement. However, in the context of social networks, individuals are inter-related. Parents of peers can be separate agents who also generate social influence. Peer ability certainly is a straight-forward channel to make sense of the influence of peer parents on student achievement. In addition, the behavioral change of own parents is also an important part of the story when their interaction with the child is endogenously affected by surrounding characteristics.

The need to understand peer parental influence is driven by its policy relevance. The type of neighborhood in which a child grows up significantly determines his/her life-time outcomes because of the exposure to surrounding environment (Chetty, Hendren and Katz, 2016; Chyn, 2018). In generating the ‘exposure effect’, social influence by surrounding adults can be an important source. To the extent that children mostly make friends with classmates, the influence of other parents is also related to classroom tracking. If important traits such as educational background of peer parents are notably related to student outcomes, grouping students by ability potentially reduces the positive influence of peer parents on disadvantaged children. Compared to the economic literature on parents and peers, the role by the parents of peers on child development is relatively less understood.

This paper assesses the significance of other parents on student achievement by re-examining the relationship between peer parental education and test score, and the underlying mechanisms. To neatly obtain a causal estimate, we require random peer group formations. The China Education Panel Survey (CEPS) duly delivers an ideal dataset, which is a national representative survey of middle school students conducted in the school year 2013-2014. We analyze a national sample of students who are randomly assigned into classes during their grade 7 in 56 schools. Our identification strategy comes from idiosyncratic within-grade variation in the college attainment of classmates’ parents. While

parent manipulations may invalidate the randomization setting, we confirm the exogeneity of class assignment by a balancing test. The random nature of this institutional setting has been well recognized in recent peer effect studies (Gong, Lu and Song, 2018, 2019; Xu, Zhang and Zhou, 2020).

Our first finding is that peer maternal education has an overall positive effect on student test scores. On average, the education spillover of a peer’s mother is equivalent to one-fifteen of the education spillover of own mother. Peer paternal education, in contrast, does not exhibit any significant spillover. The magnitude of peers’ mothers relative to peers’ fathers comes as no surprise when we consider the importance of mothers in generating inter-generational spillover (Akresh, Halim and Kleemans, 2018; Mazumder, Rosales-Rueda and Triyana, 2019).

To explore the underlying mechanisms, we take the role of other agents in a social network seriously. The CEPS matches students, teacher, and parents using a unique identifier, which is a rare feature of many national surveys. Because of the richness of this dataset, we are able to identify the behaviors of parents, which are distinct from the conventional channels of direct peer influence and teacher response. Apart from time and money, which are standard measures of parental investment on children, we borrow from the psychology literature on parenting style and construct two indexes, namely “demandingness” and “responsiveness”. The two indexes measure whether parents are strict on a number of activities and whether parents understand their child’s needs, respectively. Among time investment, monetary expenditure and the two aforementioned parenting types, maternal education of the child’s classmates significantly increases mother’s responsiveness. We find suggestive evidence that there exists a network of mothers, which facilitates knowledge spillover or the spread of norm among parents. Apart from the behavioral change of own parents, we also observe changes in pedagogical practice: teachers are more patient and praise more.

When we decompose the mechanisms following the approach by (Gong, Lu and Song, 2019), the significance of the parenting channel in driving the spillover of peer maternal

education on test score is comparable to teacher pedagogical adjustment and most of the peer quality measures. Our finding on the parenting channel echoes the growing attention on parenting style in recent economic studies (Doepke and Zilibotti, 2017; Cobb-Clark, Salamanca and Zhu, 2019).

The spillover of peer maternal education on test score is not the same for all types of students, however. We find that higher peer maternal education has a negative effect on the test score of repeaters. The spillover on migrant students is also significantly weaker than that on local students. What drives the difference is parental investment on time. Parents of repeaters and migrant students devote significantly less time on homework guidance. While repeaters and migrant students are often lower-achieving, our heterogeneity result suggests a complementarity between peer maternal education and student ability.

Broadly, our paper enriches the mechanism discussion about the spillover of peer parental education on student performance.¹ In the peer effect literature, this is called the ‘contextual effect’ generated by peer family background (Manski, 1993). Among the evidence so far, most researchers paid attention to document the ‘existence’ of a causal effect on student outcomes (McEwan, 2003; Bifulco, Fletcher and Ross, 2011; Bifulco et al., 2014). Until recently, studies started to discuss the ‘why’ behind. Fruehwirth and Gagete-Miranda (2019) show that the conventional channel of ‘peer effect’, measured by peer initial skills (both cognitive and socio-emotional skills, cannot not fully explain the spillover of peers parental education. This suggests that parental education spillover warrants attention beyond measuring peer initial skills. Olivetti, Patacchini and Zenou (2018) and Chung (2020), both analyzing a US national sample of high-school students, suggest that peer parents provide role modeling to young people. Our paper suggests that the behavioral change of parents is a non-negligible mechanism.

We also provide empirical evidence on environment-based parental style. Economic

¹Apart from educational level, other measures in the peer effect literature regarding peer family background include the number of books (Ammermueller and Pischke, 2009), domestic violence (Carrell and Hoekstra, 2010), and father’s earnings (Boisjoly et al., 2006; Black, Devereux and Salvanes, 2013).

analysis in child development mostly assumes unidirectional relationship, i.e. parent as the input and the child as the output (Becker, 1960; Weinberg, 2001; Raut and Tran, 2005; Cunha and Heckman, 2007; Guryan, Hurst and Kearney, 2008; Bono et al., 2016). Burton, Phipps and Curtis (2002) are among the first to suggest that parents should not be only regarded as exogenous inputs to child outcomes. Later, researchers started to provide more evidence that parents respond to socio-economic conditions. For example, Doepke and Zilibotti (2017) show that parents impose more control on the child if the society is more industrialized, whereas parents in lower-inequality places allow children more free choices. Agostinelli (2018) find that parents in the US spend more time with the child when the ability of the child’s friends is high. In addition to the response on time, we single out the particular role played by parenting style (Dooley and Stewart, 2007; Lizzeri and Siniscalchi, 2008; Cobb-Clark, Salamanca and Zhu, 2019).² In this manner, our result echoes the recent finding by Agostinelli et al. (2020), who show a significant relationship between parenting style and peer quality.

In the next section, we first introduce the randomization background in China and the data. In Section 3, we write down a basic linear-in-mean model and provide evidence on our identification strategy. In Section 4, we assess the importance of peer maternal education relative peer paternal education. We then analyze the underlying mechanisms driving the spillover of peer maternal education in Section 5. In Section 6, we carry out heterogeneity analysis by student characteristics. Section 7 concludes.

2 Randomization Background and Data

2.1 Randomization in Middle Schools in China

In the pre-university education system in China, a typical student in China goes through 6 years in primary school (Grade 1 to 6), 3 years in junior high school (Grade 7 to 9), and 3

²Weinberg (2001) also mentions the interaction between parental income and child-rearing practices.

years in senior high school (Grade 10 to 12). The nine-year compulsory education in China requires students to finish junior high school education before they can decide whether to continue their education in senior high school.

An assignment of students to classrooms happens at the beginning of Grade 7 which is the first year of junior high school. Students since then stay in the same class throughout the three years of middle school. While tracking is commonly used in the senior high school in China, it is explicitly prohibited in junior high school by the Ministry of Education since 2006.³ Advocated by the Ministry of Education to promote equal and fair opportunities for students in the nine-year compulsory education, a random assignment of students to the classroom increases its popularity as an alternative. Two kinds of the random assignment were mainly implemented among the junior high schools in China: purely random assignment and balanced assignment. The former uses a computer program, incorporating student demographics, classrooms, and other information, to carry the randomization process. The latter evenly assigns students into the classroom with one main restriction: classrooms with a different student composition are required to have a similar test score on average.⁴ While we cannot differentiate these two types in our analysis, both institutions are considered to be a legitimate randomization process to assess a causal impact in peer effect studies.⁵

2.2 Data and Variables

We leverage the aforementioned randomization background in China to estimate a causal effect of the educational background of peers' parents on student's outcomes. The newly-released China Education Panel Survey (CEPS) suits our purpose. It is a large-scale, nationally representative, longitudinal survey dataset hosted by the National Survey Research Center at the Renmin University of China. To date, there are two waves in CEPS.

³See "Compulsory Education Law of the People's Republic of China (2006 Amendment)", http://www.gov.cn/flfg/2006-06/30/content_323302.htm.

⁴A detailed description for the latter strategy, the "balanced assignment", can be found in Zou (2020).

⁵Recent research that exploit the same dataset and identification strategy include Hu (2015), Hu (2018), Gong, Lu and Song (2019), Eble and Hu (2019), Eble and Hu (2020), Xu, Zhang and Zhou (2020), and Zou (2020).

In Wave 1, CEPS surveys 19,487 students from both Grade 7 and 9 from 112 schools in the 2013-2014 academic year. In addition to basic demographic characteristics of students, the survey also contains parents' response and students' perception of teachers which help us to disentangle the mechanisms in the later section.⁶

Not every school in the survey adopts a random assignment policy. We follow the approach by [Gong, Lu and Song \(2018\)](#) to determine which schools adopt the randomization policy. First, the school principal reports that a randomization process is used for arranging new students into classrooms; and second, the principle confirms that students will not be reassigned to a different classroom in their Grade 8 and 9; and third, all headteachers in the Grade 7 report that students are not assigned by test scores. Our selected sample is almost identical to that of [Gong, Lu and Song \(2018\)](#). The only difference is that we further dropped the grades with only one class, as we are making use of the variations across classrooms within the same grade in a middle school. The dropped sample consists of 269 students across 6 classrooms of 6 schools. This leads to 64 schools remain, which is 57.1% of the school sample. Further, we exclude 22 students with either father's or mother's educational standing not available. In fact, students without maternal education is identical to the student sample whose father's education is not available. Therefore, either dropping students without maternal education or dropping students without father's education will lead to the same result. Thus, the remaining sample in Wave 1 consists of 8,696 students across 202 classrooms in 64 schools.

Our outcome variable is the total test score obtained by summing up midterm exam scores in Chinese, Mathematics, and English of students at Grade 7 and 9. These subjects are the core courses in China's middle schools. In the raw data, the scores of the three subject have been standardized with mean 70 and standard deviation 10. We generate the total score by firstly summing up the standardized scores in the three subjects and then standardizing the total score at the school-grade level with mean 0 and standard deviation

⁶More discussion on related variables in Section 5.

1. Throughout the article, peers are defined as classmates. On average, there are 47 students in each class with a minimum of 15 and a maximum of 81.

The key variable of interest is the educational background of peers’ parents. We measure it by the average college attainment of classmates’ mothers and fathers separately. To avoid spurious correlation, we follow the approach by [Moffitt et al. \(2001\)](#) to calculate the ‘leave-me-out’ average. We use pre-determined variables of students to implement balancing tests for the random assignment and include them as controls in the main specifications. The control variables include age, gender, ethnicity, rural status, local residency status, only child indicator, whether one attended kindergarten, student’s age attending primary school, whether one repeated or skipped in primary school, non-cognitive measures and parental college education attainment.⁷ In [Table 1](#), we provide summary statistics for the aforementioned variables.

⁷For the non-cognitive measures: CEPS asks students seven questions on personality traits at Grade 6. The first three questions measure persistence, while the rest measures other personality traits. We follow the approach by [Zou \(2020\)](#) and [Gong, Lu and Song \(2018\)](#) to obtain a “persistence” index by averaging the responses of the first three questions and a “other non-cognitive” measure by averaging the responses of the rest four.

Table 1: Summary Statistics

| | N | Mean | SD | Min | Max |
|--|-------|-------|-------|-------|-------|
| A. Outcome variables | | | | | |
| Total score | 8,445 | 210.1 | 26.21 | 77.97 | 293.9 |
| B. Variables of interests: | | | | | |
| Parental education: | | | | | |
| Mother's education | 8,696 | 0.108 | 0.311 | 0 | 1 |
| Father's education | 8,696 | 0.137 | 0.344 | 0 | 1 |
| Peer variables: | | | | | |
| Peer mother's education | 8,696 | 0.108 | 0.137 | 0 | 0.656 |
| Peer father's education | 8,696 | 0.137 | 0.159 | 0 | 0.929 |
| C. Control variables: | | | | | |
| Student age | 8,530 | 14.48 | 1.231 | 12 | 18 |
| Female student | 8,696 | 0.488 | 0.500 | 0 | 1 |
| Minority | 8,677 | 0.112 | 0.315 | 0 | 1 |
| Agricultural Hukou | 8,241 | 0.444 | 0.497 | 0 | 1 |
| Nonlocal residence | 8,639 | 0.182 | 0.386 | 0 | 1 |
| Only child in family | 8,582 | 0.524 | 0.499 | 0 | 1 |
| Attend kindergarten | 8,626 | 0.820 | 0.385 | 0 | 1 |
| Age attending primary school | 8,597 | 6.564 | 1.023 | 0 | 9 |
| Repeat grade in primary school | 8,676 | 0.101 | 0.301 | 0 | 1 |
| Skip grade in primary school | 8,677 | 0.015 | 0.121 | 0 | 1 |
| Persistence at Grade 6 | 8,360 | 3.330 | 0.694 | 1 | 4 |
| Other non-cognitive measure at Grade 6 | 8,200 | 3.183 | 0.608 | 1 | 4 |

Note: The initial sample consists of 8,696 students, where the detail of sample selection is described in Section 2.2. Observation varies across variables because some have missing values.

3 Identification Strategy

3.1 Linear-in-Mean Model

To estimate the spillover of peer parental education on student academic outcomes, we use the following linear-in-mean model (Moffitt et al., 2001; Sacerdote, 2011):

$$Y_{i,j,k} = \beta_0 + \beta_1 \overline{MotherEdu}_{-i,j,k} + \beta_2 MotherEdu_{i,j,k} + X'_{i,j,k} \gamma + T'_{j,k} \phi + P'_{j,k} \lambda + \delta_k + \epsilon_{i,j,k} \quad (1)$$

where $Y_{i,j,k}$ refers to the test score of student i in class j in a school-grade k . $\overline{MotherEdu}_{-i,j,k}$ is the leave-me-out average college attainment of mothers in a classroom. $X'_{i,j,k}$ is a vector of control variables listed in Table 1.⁸ We isolate the effect of teacher characteristics ($T'_{j,k}$) on students by including head teachers' age, gender, marriage status, whether having a college degree, teaching experience in years, whether graduated from a normal college, and whether having a teacher certificate (Gong, Lu and Song, 2018).

We include school-by-grade fixed effect (δ_k) to control for school and residential sorting. With the fixed effect, the variation of $\overline{MotherEdu}_{-i,j,k}$ then entirely comes from within-grade classroom composition, which is the level the randomization happens. Our randomization setting is rare and unique, especially with a national sample of students. An analogous dataset in the US is the National Longitudinal Study of Adolescent to Adult Health (Addhealth), which contains actual friendship detail for a national sample of US students and is widely used in the peer effect literature. Because of the concern over individual sorting into peer groups, researchers require additional assumptions to identify the spillover of peer parental education (Bifulco, Fletcher and Ross, 2011; Bifulco et al., 2014; Olivetti, Patacchini and Zenou, 2018; Chung, 2020).

$P'_{j,k}$ refers to a vector of peers' characteristics (the classroom percent of female, migrant, repeater, and average of classmates' persistence index), which are found to represent significant peer influence (Golsteyn, Non and Zölitz, 2017; Gong, Lu and Song, 2018, 2019;

⁸We will explain the inclusion of peer paternal education as a robustness check later.

Xu, Zhang and Zhou, 2020; Zou, 2020). Because we are interested in the mechanisms other than the conventional peer effect channel, we control for the above peers’ characteristics to isolate peer spillover in the decomposition exercise.

3.2 Test for Random Class Assignment

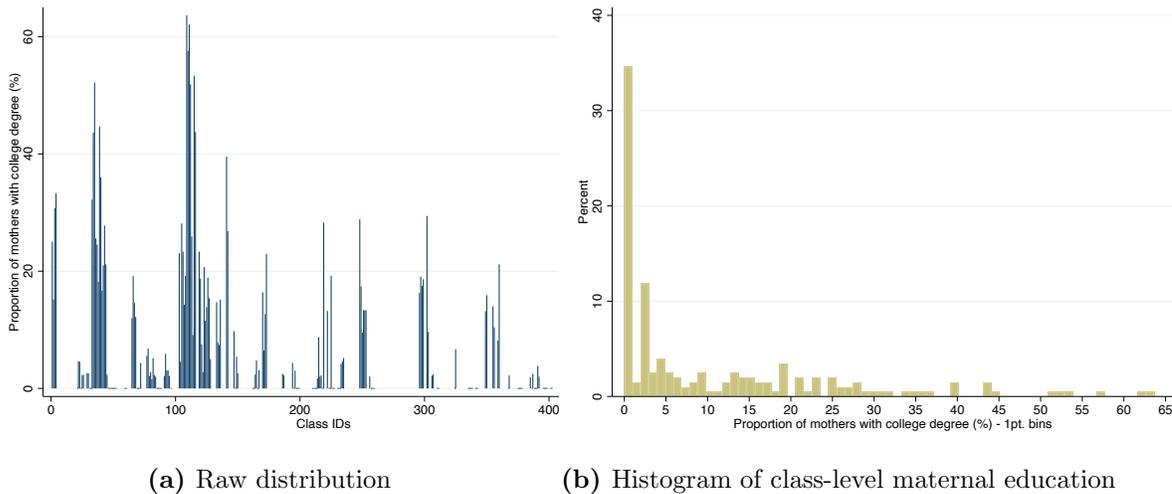
Before we estimate the spillover of peers’ maternal education, we verify the peer group assignment is as good as random. Because our identification relies on within-grade variations of classroom composition, we need to make sure there are ample variations of the treatment variable.⁹

Figure 1a shows the raw distribution of the class-level proportion of mothers with a college degree across classes, where the x-axis represents the class identifier and the y-axis shows the class-level proportion of college-graduating mothers. We further organize the values into a histogram in Figure 1b. As shown, the classroom proportion of mothers with a college degree varies from 0 to 63.64 percentage points. In Figure 2a, we show the correlation in maternal education between classes, conditional on the same school-grade. Each dot represents a school-grade, with the proportion of college graduating mothers in classroom 1 on the x-axis and that in classroom 2 on the y-axis. The idea is to see if two classrooms have the same value, in which the dot will fall exactly on the 45-degree line. As shown, many dots scatter around, implying substantial variations in our treatment variable even controlling for school-by-grade fixed effect. On the flip side of the same coin, Figure 2b plots a histogram of within-grade between-class differences in the proportion of college-graduating mothers. The difference ranges from 0 to 28.30 percentage points, with more than 60% of the class pairs not having the same value. This again shows there are enough variations of our treatment variable for identification.

In Table 2, we perform a balancing test, regressing the (leave-me-out) average college attainment of peers’ mother and father separately on students’ pre-determined variables.

⁹We conduct another same set of analysis for class-level fathers’ education in Figure 1 and 2 of the Appendix.

Figure 1: Variation of class-level maternal education

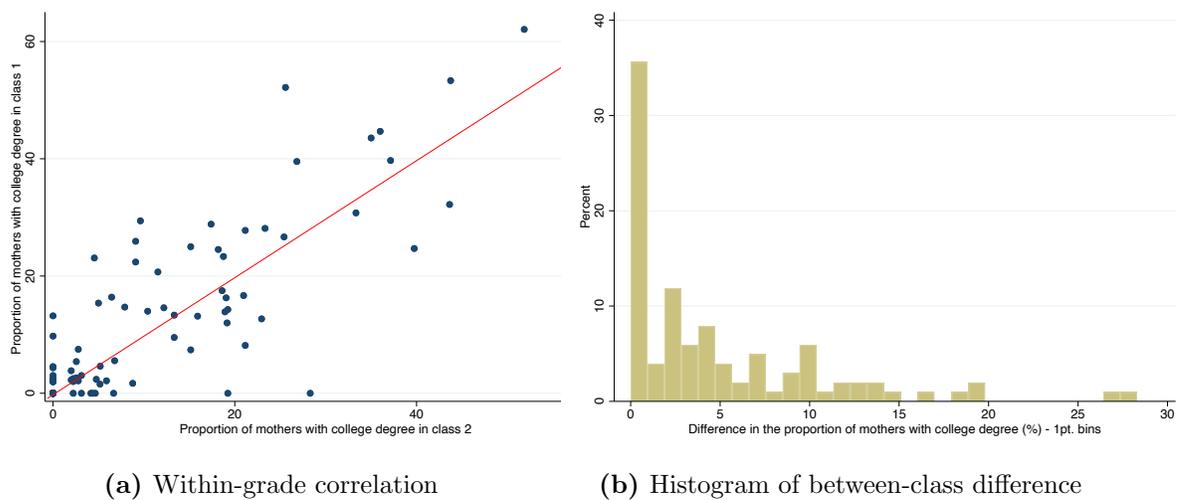


Note. Figure 1a shows the raw distribution of the proportion of mothers with a college degree across classes. Figure 1b plots the histogram of proportion of mothers with college degree (shown in 1 percentage-point bins). The proportion of mothers with a college degree ranges from 0 to 63.64 percentage points.

The idea is to see if student characteristics significantly predict the treatment variable. If the assignment is truly random, we should observe weak relationships. As shown in Column 2 and 4, without school-grade fixed effects, most of the student characteristics are highly correlated with parental education of classmates. For example, classmates' parents of better or privileged students (e.g. non-repeaters, an ethnic majority) tend to have more education. This corresponds to the concern over the neighborhood or school sorting.

In Column 1 and 3, we add school-grade fixed effects. Conditional on the same school and grade, which is the level that random assignment occurs, most of the correlation between student characteristics and peer parental education disappears. The magnitude of the coefficients is both economically and statistically insignificant. While 'only child' and repeater status are seemingly related to classmates' paternal education, the magnitude is small and the correlation is only significant at 10% level. There might still be a worry that parents intervene in classroom assignments, though tracking is prohibited by law. However, we verify here that the concern over parental manipulation is minimal.

Figure 2: Variation of class-level maternal education within each school-grade



Note. Figure 2a plots the proportion of mothers with college degree across two classes within each school-grade. Figure 2b plots the histogram of differences of proportion of mothers with college degree in two classes within each school-grade (shown in 1 percentage-point bins). The within school-grade differences of proportion of mothers with college degree ranges from 0 to 28.30 percentage points.

Table 2: Balancing Test for Random Assignment

| | Peer maternal education | | Peer paternal education | |
|--|-------------------------|----------------------|-------------------------|----------------------|
| | (1) | (2) | (3) | (4) |
| Student age | -0.000 (0.001) | 0.002 (0.007) | -0.000 (0.001) | 0.003 (0.008) |
| Female student | 0.001 (0.001) | 0.008** (0.003) | 0.001 (0.001) | 0.007** (0.003) |
| Minority | -0.002 (0.001) | -0.025*** (0.008) | -0.002 (0.002) | -0.031*** (0.010) |
| Agricultural Hukou | -0.002 (0.002) | -0.085*** (0.011) | -0.003 (0.002) | -0.100*** (0.012) |
| Non-local residence | -0.002 (0.002) | 0.021** (0.009) | -0.001 (0.002) | 0.028*** (0.011) |
| Only child in family | 0.003 (0.002) | 0.039*** (0.006) | 0.003* (0.002) | 0.044*** (0.008) |
| Attend kindergarten | -0.000 (0.001) | 0.024*** (0.006) | 0.002 (0.002) | 0.030*** (0.006) |
| Age attending primary school | -0.001 (0.001) | -0.011*** (0.003) | -0.001 (0.001) | -0.015*** (0.004) |
| Skip grade in primary school | -0.006 (0.007) | -0.011 (0.014) | -0.003 (0.007) | -0.011 (0.015) |
| Repeat grade in primary school | -0.001 (0.001) | -0.036*** (0.007) | -0.003* (0.002) | -0.047*** (0.009) |
| Persistence at Grade 6 | -0.001 (0.001) | -0.008*** (0.004) | -0.000 (0.001) | -0.010** (0.004) |
| Other non-cognitive measure at Grade 6 | 0.001 (0.001) | 0.013*** (0.003) | 0.001 (0.001) | 0.011*** (0.004) |
| Maternal education | -0.005 (0.004) | 0.112*** (0.016) | | |
| Paternal education | | | -0.006 (0.004) | 0.122*** (0.019) |
| School-Grade FE | yes | no | yes | no |
| Observations | 7,376 | 7,376 | 7,376 | 7,376 |

Note: Each column represents a separate regression which regress the peer maternal/paternal education on student's pre-determined variables. Regression in column (1) and (3) includes school-grade fixed effects. Robust standard errors clustered at the school-grade level are in brackets. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

4 Peer Parental Education and Test Score

In Table 3, we first establish the relationship between peer parental education and student performance.¹⁰ Column 1 shows the bi-variate relationship conditional on the school-by-grade fixed effect. As expected, the educational level of classmate mothers is positively related to a student’s achievement. Although the coefficient of peer maternal education is three times larger than that of own parental education, the comparison needs to take into account the average class size. We leave the interpretation to the fully saturated model in Column 4. In Column 2 and 3, the magnitude remains salient and significant when we control for student and headteacher characteristics.¹¹

In Column 4, we probe the role of the most intuitive mechanism that drives the spillover of peer maternal education - peer interaction. We included female, migrant, ability (ever repeated grade as the proxy), and a persistence measure as the four main peers’ characteristics. Tracing the change in the coefficients, the magnitude of peer maternal spillover drops by 20%. The bottom line is the peer effect channel matters. However, it is not the entire channel behind the spillover of peer maternal education. Conditional on the rich set of covariates and fixed effects in Column 4, the magnitude of peer maternal spillover remains statistically significant.

The raw coefficient of peer maternal education appears to be bigger than that of own maternal education. However, to correctly compare their magnitude, we need to take into account the class size. A 30-percent increase in the college attainment rate of classmates’ mothers would move up a student’s test score by 0.27 standard deviations, which is more or less the same as the effect of having a college-graduating mother. For a class of 50 students (average class size), this amounts to fifteen college-graduating classmates’ mothers. In Table

¹⁰Because there are missing values in both the outcome and controls variables, the sample size in the main results is smaller than the sample size we had in the summary statistics.

¹¹Because the students were randomly assigned to classrooms within each school-grade, the head teacher’s characteristics also generate exogenous variances across classes within each school-grade. We conduct the balancing tests for head teacher’s characteristics in the Appendix Table A1, by regressing the class-level maternal/paternal education average on characteristics of headteacher with school-grade fixed effects.

A2 of the Appendix, we also examine the effect of peers’ mother college education by subject. The spillover is stronger in Chinese and Mathematics.

Table 3: Peers’ Maternal Education Affects Student Performance

| | Std. total test scores | | | |
|-------------------------------------|------------------------|---------------------|---------------------|---------------------|
| | (1) | (2) | (3) | (4) |
| Peer maternal education | 1.516*** (0.429) | 1.418*** (0.412) | 1.149** (0.409) | 0.909** (0.426) |
| Maternal education | 0.295*** (0.033) | 0.268** (0.032) | 0.263*** (0.031) | 0.259*** (0.032) |
| School-Grade FE | YES | YES | YES | YES |
| Student Controls | NO | YES | YES | YES |
| Teacher Controls | NO | NO | YES | YES |
| Peer’s Chara.# | NO | NO | NO | YES |
| Joint test p-value of peer’s chara. | – | – | – | 0.01 |
| Observations | 7,053 | 7,053 | 7,053 | 7,053 |
| R-squared | 0.002 | 0.090 | 0.097 | 0.103 |

Note: The dependent variables are total scores standardized by grade and school, to obtain a zero mean and one standard deviation. ‘Peer maternal education’ refers to the leave-one-out average college attainment of classmates mothers, while ‘Maternal education’ is a dummy indicating whether the student’s mother has a college degree. The student controls include age, gender, minority, hukou status, migrant status, whether from one child family, whether attended kindergarten, age attending primary school, non-cognitive measure at Grade 6, whether skip grade and whether repeat grade in primary school, and parental education attainment. The teacher controls include headteacher’s age, gender, teaching experience, and dummy variables indicating marital status, had professional job title, had college degree or above, and graduated from a normal college. Peer controls include the classroom proportion of female, migrant and low-ability peer, and peers’ persistence. Robust standard errors clustered at school-grade level are in brackets. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

In Table 4, we assess the role of peer mothers relative to peer fathers and replicate the above decomposition exercise. Peer paternal education does have a positive effect on a student’s test score as revealed by Column 1. However, its effect is not significantly different from zero. Its magnitude is also smaller than that of peer maternal education. The positive coefficient of peer paternal education fades out when we include the full set of control variables in Column 4. At the same time, the coefficient on peer maternal education is slightly inflated compared to Column 4 in Table 3. This could be expected given the correlation between peer maternal and peer paternal education. However, because the estimates on peer maternal education between Table 3 and Table 4 are not statistically distinguishable, ignoring the peer paternal education is not a concern when we estimate the effect of peer maternal education. For a better focus, the model with only peer maternal education is our

preferred specification throughout the paper. Overall, Table 4 shows that peer fathers do not generate the same magnitude of spillover as peer mothers do on student test scores.

Table 4: Peers’ Fathers Do Not Generate Spillover

| | Std. total test scores | | | |
|-------------------------|------------------------|--------------------|---------------------|---------------------|
| | (1) | (2) | (3) | (4) |
| Peer maternal education | 1.300** (0.553) | 1.291** (0.519) | 1.312** (0.529) | 1.259** (0.482) |
| Peer paternal education | 0.304 (0.574) | 0.179 (0.499) | -0.237 (0.416) | -0.509 (0.405) |
| Maternal education | 0.294*** (0.033) | 0.267** (0.032) | 0.264*** (0.032) | 0.261*** (0.032) |
| School-Grade FE | YES | YES | YES | YES |
| Student Controls | NO | YES | YES | YES |
| Teacher Controls | NO | NO | YES | YES |
| Peer’s Chara.# | NO | NO | NO | YES |
| Observations | 7,053 | 7,053 | 7,053 | 7,053 |
| R-squared | 0.002 | 0.090 | 0.097 | 0.103 |

Note: The dependent variables are total scores standardized by grade and school, to obtain a zero mean and one standard deviation. ‘Peer maternal (paternal) education’ refers to the leave-one-out average college attainment of classmates mothers (fathers), while ‘Maternal education’ is a dummy indicating whether the student’s mother has a college degree. The student controls include age, gender, minority, hukou status, migrant status, whether from one child family, whether attended kindergarten, age attending primary school, non-cognitive measure at Grade 6, whether skip grade and whether repeat grade in primary school, and parental education attainment. The teacher controls include headteacher’s age, gender, teaching experience, and dummy variables indicating marital status, had professional job title, had college degree or above, and graduated from a normal college. Peer controls include the classroom proportion of female, migrant and low-ability peer, and peers’ persistence. Robust standard errors clustered at school-grade level are in brackets. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

5 Mechanisms

In this section, we investigate several potential mechanisms that could explain the positive spillovers generated by peers’ maternal education: peer effect among students, parental investment of students’ own parents, and teacher’s behavioral response.

5.1 Peers’ Skill

Studies on peer effects have heavily discussed how peers in a classroom or school could affect one’s outcomes ¹² Therefore, the first apparent mechanism for the positive spillover of peer maternal education on student achievement can be described as follows: Students with higher educated mothers have higher ability due to inherited endowment. They are themselves high-achieving peers who affect their classmates’ outcomes through daily interaction.

In Table 3, we detect the peer effect channel by examining the joint significance of the four peers’ characteristics. Ideally, to capture peer spillover associated with family background, we would need to control for students’ ability such as baseline test scores. However, this information is not available in the CEPS. Therefore, our second best solution is to control for the four pre-determined characteristics of classmates, which are also found to have profound impacts on student academic performance (Gong, Lu and Song, 2019; Hu, 2018; Xu, Zhang and Zhou, 2020; Zou, 2020). According to the p-value in Table 3, they are also jointly significant at 1% level, suggesting that the peer effect channel matters.

An important point to note is that our variable on peer maternal education is beyond a measure of peer quality. For example, in a recent study by Cools, Fernández and Patacchini (2019), they use parental education to proxy for peer’s ability. While we acknowledge the significance of peer ability endowment, our focus is rather on the residual influence of peer maternal education after taking into account the peer effect channel. As suggested in the fully saturated model in Table 3, spillover among peers is only a part of the story of peers’ maternal

¹²For peer effect studies in the educational setting, see a survey by Sacerdote (2011). Some recent studies include Feld and Zölitz (2017), Carrell, Hoekstra and Kuka (2018), and Bursztyn, Egorov and Jensen (2019).

education spillover. The residual influence of peer maternal education on student test score indeed remains salient. We then investigate whether educated mothers of classmates could affect students' outcomes through other channels, such as students' own parents and teachers.

5.2 Parental Response

The complementarity/substitutability between parental and non-parental inputs (such as government welfare programs and school policies) to a child is not new in the economic literature (BonesrØnning, 2004; Datar and Mason, 2008; Adhvaryu and Nyshadham, 2016). Until recently, researchers started to provide general arguments about environment-based parental response (Burton, Phipps and Curtis, 2002). Doepke and Zilibotti (2017) provides a framework to understand how parents' parenting style responds to the surrounding environment, for example, the composition of parents' education attainment in the same neighborhood. The closet study to our mechanism discussion is by Agostinelli (2018), who shows that parental time investment changes with the ability of the child's peers.

Therefore, we propose a possible hypothesis to explain the peer parental spillover: parents respond to the parental background of the child's classmates. Norms and exchange of information are possible but not exhaustive reasons behind the change in parenting. In addition to standard measures of time and monetary investment, we also investigate the change in parenting style.

Parenting style measures the quality of parent-child attachment, which is different from time and monetary investment. The concept of parenting in affecting child development is rather new compared to the classical analysis by Becker (1965) and Michael and Becker (1973), where the human capital production function considers time and market goods as the two inputs. In the developmental psychology literature, Baumrind (1967) first proposed three different parenting styles: "permissive", "authoritarian", and "authoritative" parenting. Later, this parenting style framework was extended by including the "neglecting" as the fourth parenting style McCoby and Martin (1983). The essence of the parenting style

is the relative amount of demandingness (control) and responsiveness (warmth) involved in parent-child interaction. These two components have long been regarded as a key for child development in psychology literature (Darling and Steinberg, 1993; Spera, 2005). In economics, Aizer and Cunha (2012); Burton, Phipps and Curtis (2002); Cunha and Heckman (2007); Cunha (2015) are among the first to formalize the importance of parenting into economic models, who in general regard parenting style as an input of skill formation of a child.

We make use of the rich information in CEPS about parent-child interaction to measure ‘responsiveness’ and ‘demandingness’. A ‘responsiveness’ index is constructed based on five questions regarding how often a parent discuss certain things with the child.¹³ For the ‘demandingness’ index, we make use of eight questions to measure the extent to which a parent controls over a child’s choices.¹⁴ To offer an easier interpretation, we standardize both indexes.¹⁵ We also follow Kling, Liebman and Katz (2007) to estimate the mean effect size, which reflects the aggregated effects and helps to address the multiple hypothesis testing issues.

Table 5: Mothers Become More Responsive

| | Responsiveness | Demandingness | Responsiveness MES | Demandingness MES | Responsiveness | Responsiveness | Demandingness | Demandingness |
|-------------------------|--------------------|-------------------|-----------------------|----------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Peer maternal education | 0.751** (0.305) | -0.011 (0.367) | 0.607** (0.245) | -0.007 (0.246) | 1.155** (0.483) | 0.589 (0.485) | -0.126 (0.497) | 0.216 (0.522) |
| Maternal education | 0.188** (0.043) | -0.012 (0.045) | 0.152*** (0.035) | -0.008 (0.030) | 0.236*** (0.051) | 0.045 (0.076) | 0.057 (0.058) | -0.168** (0.074) |
| Sample | Full | Full | Full | Full | Mother as survey responder | Father as survey responder | Mother as survey responder | Father as survey responder |
| Observations | 6,876 | 6,807 | 6,876 | 6,807 | 3,530 | 2,929 | 3,499 | 2,896 |
| R-squared | 0.168 | 0.094 | – | – | 0.166 | 0.132 | 0.074 | 0.118 |

Note: The dependent variables are the corresponding index of parenting style. The indexes are standardized over the estimation sample. MES = mean effect size following Kling et al. (2007). ‘Peer maternal education’ refers to the leave-one-out average college attainment of classmates mothers, while ‘Maternal education’ is a dummy indicating whether the student’s mother has a college degree. All regressions control for characteristics of students, teachers, peer effects, and school-by-grade fixed effects. The student controls include age, gender, minority, hukou status, migrant status, whether from one child family, whether attended kindergarten, age attending primary school, non-cognitive measure at Grade 6, whether skip grade and whether repeat grade in primary school, and parental education attainment. The teacher controls include headteacher’s age, gender, teaching experience, and dummy variables indicating marital status, had professional job title, had college degree or above, and graduated from a normal college. Peer controls include the classroom proportion of female, migrant and low-ability peer, and peers’ persistence. Robust standard errors clustered at school-grade level are in brackets. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

¹³For the ‘responsiveness’ index, we utilize the question “How often do you discuss the following with your child?” with a scale from 1 (never) to 3 (often) on five aspects: (1) things happened at school, (2) relationship between the student and her friends, (3) relationship between the student and her teachers, (4) student’s feelings, and (5) student’s worries and troubles.

¹⁴To measure ‘demandingness’, we base on the question “Do you care and are you strict with your child about the following?” with a scale from 1 (don’t care) to 3 (very care) on eight aspects: (1) homework and examination, (2) behavior at school, (3) daily attendances, (4) daily time student get back home, (5) whom to make friends with, (6) dress style, (7) time spent on the Internet, and (8) time on watching TV.

¹⁵We first standardize the sub-components. After taking the average, we standardize again the average.

The evidence on peer-based parenting style is presented in Table 5. In the first two columns, we first aggregate the responses from mother and father. As in Column 1, when maternal education of the child’s classmates is higher, the responsiveness of parents increases. A 10-percent increase in the college attainment rate of the mothers of a child’s classmates raises a mother’s responsiveness by 0.075 standard deviation. It is about two-fifth (0.075/0.188) of the education effect of own mother. In contrast, as in Column 2, maternal education of the child’s classmates has precisely zero effect on demandingness.

To reduce the chance of false positives, we follow [Kling, Liebman and Katz \(2007\)](#) to compute the mean effect size (MES) in Column 3 and 4 for the two parenting measures. Intuitively, MSE is a weighted average of treatment effect estimates on different outcome variables.¹⁶ The effect on responsiveness remains robust as shown in Column 3.

We further differentiate the response of mothers from that of fathers. As shown in Column 5 and 6, mothers but not fathers become more responsive when surrounding mothers are more educated. Moreover, the estimate in Column 5 obtained by only using the mother sample is larger than the estimate we observe using the aggregated response in Column 1 and 3, which suggests the change in parenting style is primarily from mothers.

The change in parenting style in response to other mothers’ background is distinct from other types of parental investment in classical economic models. In Table 6, the education of other mothers has no significant impact on time (Column 1 and 2) and monetary investment (Column 3 and 4).

In Table 7, we provide suggestive evidence that there exists a spillover in knowledge among parents, which potentially explains the change in parenting style above. In Column 2, a parent is more likely to know the parents of the child’s classmates when other mothers are

¹⁶Following [Kling, Liebman and Katz \(2007\)](#), the way we construct the MES is first to estimate the treatment effect for each outcome, then take the average of their standardized values. Specifically, the MES of peer mothers’ education on outcome k in parenting category c is defined as the following: $MES_c = (1/n_c) \sum_{n=1}^{n_c} e_{kc}/\sigma_{kc}$, where n_c is the number of outcomes in category c , e_{kc} is the estimate of impact of peer mothers’ education on outcome k , and σ_{kc} is the standard deviation of the outcome variable of the control group. The standard error and p-value of MES are calculated by following the method provided in the Web Appendix B of [Kling, Liebman and Katz \(2007\)](#). See Appendix Table A3 and A4 for the estimates on each factor item used to come up with the two parenting indexes

Table 6: Parental Investments on Time and Money Do Not Respond

| | Time spent with child per day (1) | “Did you guide your child with her HW last week” (2) | “Does this child take any tutoring this semester” (3) | Tutoring fee spent this semester (4) |
|-------------------------|---|---|--|--|
| Peer maternal education | 0.076 (2.871) | -0.470 (0.404) | 0.055 (0.187) | 0.310 (1.319) |
| Maternal education | -0.225 (0.229) | 0.230*** (0.052) | 0.041* (0.022) | 0.331* (0.189) |
| Observations | 7,248 | 4,556 | 6,980 | 6,722 |
| R-squared | 0.052 | 0.210 | 0.373 | 0.405 |

Note: The dependent variables are measurements representing parental investment on time and money. ‘Peer maternal education’ refers to the leave-one-out average college attainment of classmates mothers, while ‘Maternal education’ is a dummy indicating whether the student’s mother has a college degree. All regressions control for characteristics of students, teachers, peer effects, and school-by-grade fixed effects. The student controls include age, gender, minority, hukou status, migrant status, whether from one child family, whether attended kindergarten, age attending primary school, non-cognitive measure at Grade 6, whether skip grade and whether repeat grade in primary school, and parental education attainment. The teacher controls include headteacher’s age, gender, teaching experience, and dummy variables indicating marital status, had professional job title, had college degree or above, and graduated from a normal college. Peer controls include the classroom proportion of female, migrant and low-ability peer, and peers’ persistence. Robust standard errors clustered at school-grade level are in brackets. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

more educated. This response is driven by mothers but not fathers as shown in Column 3, and 4. Therefore, the adjustment by mothers in response to the education of other mothers can be understood as a rational choice when social influence is taken into account, for example, learning the know-how or the pressure to conform to the norm of success.

Table 7: Explanation Behind the Change in Parenting Style

| | (1) “Do you know your kid’s friends” | (2) “Do you know parents of your kid’s friends” | (3) “Do you know parents of your kid’s friends” | (4) “Do you know parents of your kid’s friends” |
|-------------------------|--|---|---|---|
| Peer maternal education | 0.089 (0.085) | 0.353** (0.146) | 0.550*** (0.197) | 0.051 (0.269) |
| Maternal education | 0.010 (0.012) | 0.013 (0.019) | 0.001 (0.024) | 0.039 (0.032) |
| Observations | 6,804 | 6,098 | 3,217 | 2,518 |
| R-squared | 0.035 | 0.045 | 0.033 | 0.070 |
| Sample | Full | Full | Mother as responder | Father as responder |

Note: The Dependent variables are dummies indicating parent’s knowledge on kid’s friends and other parents, respectively. ‘Peer maternal education’ refers to the leave-one-out average college attainment of classmates mothers, while the ‘Maternal education’ is a dummy indicating whether any of students’ parents has a college degree. The student controls include age, gender, minority, hukou status, migrant status, whether from one child family, whether attended kindergarten, age attending primary school, persistence and non-cognitive measure at Grade 6, whether skip grade and whether repeat grade in primary school, and parental education attainment. The teacher controls include headteacher’s age, gender, teaching experience, and dummy variables indicating marital status, had professional job title, had college degree or above, and graduated from a normal college. Peer controls include the classroom proportion of female, migrant and low-ability peer, and peers’ persistence. Robust standard errors clustered at school-grade level are in brackets. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

5.3 Teacher Response

Teachers may also play a role in contributing to peer parental spillover. A possibility is through enhanced teacher-parent interaction. There are two specific questions asking parents about parent-teacher contacts, regarding how often the teacher or the parent initiates a contact. The answers for both questions consist of 4 responses: never, once, two to four times, and five times or more. We generate a dummy variable to indicate whether the student's teacher contacted the parents this semester. In Column 1 and 2 of Table 8, in general, educated parents have more interaction with the teacher. However, we do not observe any evidence on strengthened parent-teacher interaction due to a higher classroom's maternal education.

It does not mean that teachers are not responsible for any classroom spillover. For example, [Lavy, Paserman and Schlosser \(2012\)](#), [Hu \(2018\)](#) and [Gong, Lu and Song \(2019\)](#) find that teachers adjust teaching style and effort according to the proportion of repeaters, migrant, or female in a class, which in turn affects the students in the same classroom. To test if there are changes in pedagogical practices, we make use of the parent and student questionnaire about their experience with or perception of teachers to examine teacher spontaneous responses. In the parent questionnaire, two questions were asked to parents on "Do you think the teachers are responsible/patient to your kid" with a scale from 1 (not at all) to 5 (very). In the Students questionnaire, students were asked the following questions with a scale from 1 (strongly disagree) to 4 (strongly agree): (1) my headteacher always praises me; (2) my headteacher always criticizes me. As shown from Column 3 to 4 of Table 8, students' parents hold the opinion that kids' teachers are more responsible and patient when the classroom's maternal education is higher. The headteacher also praises more, as shown in Column 5.

Table 8: Teacher Pedagogical Response

| | “Whether teacher contact parents” (1) | “Whether parents contact teacher” (2) | “Teacher is responsible” (3) | “Teacher is patient” (4) | “Headteacher always praises me” (5) | “Headteacher always criticize me” (6) |
|-------------------------|---|---|------------------------------------|--------------------------------|---|---|
| Peer maternal education | 0.071 (0.245) | 0.070 (0.145) | 0.737** (0.307) | 0.665** (0.296) | 0.632** (0.300) | -0.241 (0.348) |
| Maternal education | 0.037** (0.017) | 0.048*** (0.014) | 0.040 (0.032) | 0.059** (0.028) | 0.167*** (0.033) | -0.070*** (0.026) |
| Observations | 6,930 | 6,979 | 6,983 | 6,971 | 7,201 | 7,206 |
| R-squared | 0.100 | 0.075 | 0.127 | 0.130 | 0.140 | 0.048 |

Note: Column (1) and (2) are analyzed at the parents level, while column (3) and (4) are analyzed at the student level. ‘Peer maternal education’ refers to the leave-one-out average college attainment of classmates mothers, while ‘Maternal education’ is a dummy indicating whether the student’s mother has a college degree. All regressions control for characteristics of students, teachers, peer effects, and school-by-grade fixed effects. The student controls include age, gender, minority, hukou status, migrant status, whether from one child family, whether attended kindergarten, age attending primary school, non-cognitive measure at Grade 6, whether skip grade and whether repeat grade in primary school, and parental education attainment. The teacher controls include headteacher’s age, gender, teaching experience, and dummy variables indicating marital status, had professional job title, had college degree or above, and graduated from a normal college. Peer controls include the classroom proportion of female, migrant and low-ability peer, and peers’ persistence. Robust standard errors clustered at school-grade level are in brackets. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

5.4 Decomposition

We uncovered two mechanisms other than the peer effect channel. In this subsection, we assess their relative importance. In Table 9, we trace the change in the coefficient of peer maternal education, with and without controlling for the mechanisms. Column 1 is essentially the same as Column 3 of Table 3 in the main analysis, where we only control for standard characteristics of student and teacher conditional on school-by-grade fixed effect. Another way to interpret the coefficient is the residual influence of peer maternal education on a student test score, after taking into account potential school sorting. In Column 2, we perform the same specification as in Column 1 using a reduced sample. The sample size is smaller because there are missing values for teacher or parent responses. We reproduce the baseline result here for a comparison. In Column 3, the magnitude of the coefficient on peer maternal education drops by about half when we include the mechanism variables, namely peers’ characteristics (gender, repeater indicator, migrant status, and persistence measure) to proxy for peer effect, teacher responses in Column 3 to 5 in Table 8, and parenting style (responsiveness, demandingness). The residual variation of peer maternal education after controlling for the three mechanisms is no longer significantly related to a student test score. Peers, teachers, and own parents together, though not exhaustively, explained a significant amount of peer maternal spillover.

Table 9: Peer, Teacher, and Parent Channels Explained Away The Spillover of Peer Maternal Education

| | Std. total test scores | | |
|-------------------------|------------------------|-----------------------|-----------------------|
| | Full sample (1) | Reduced sample (2) | Reduced sample (3) |
| Peer maternal education | 1.149*** (0.409) | 0.920** (0.405) | 0.439 (0.435) |
| Constant | 0.874* (0.519) | 0.807 (0.522) | -0.541 (0.607) |
| Observations | 7,053 | 6,430 | 6,430 |
| Adjusted R-squared | 0.0967 | 0.0924 | 0.139 |
| Peer channel | NO | NO | YES |
| Teacher channel | NO | NO | YES |
| Parent channel | NO | NO | YES |

Note: ‘Peer maternal education’ refers to the leave-one-out average college attainment of classmates mothers. All regressions control for characteristics of students, teachers, and school-by-grade fixed effects. Robust standard errors clustered at school-grade level are in brackets. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

We further decompose the aforementioned mechanisms (Heckman, Pinto and Savelyev, 2013; Gelbach, 2016; Gong, Lu and Song, 2019). The essence of this exercise is to assess to what extent a mechanism explain the effect of peer maternal education on student test score. It is particular useful in our context to evaluate the significance of parental adjustment as a novel mediating factor. For the below formal equations, we follow closely the notation by Gong, Lu and Song (2019). Assuming a mechanism variable for student i as $m_{i,j,k}^c$,

$$m_{i,j,k}^c = \alpha_0 + \alpha_1^c \overline{MoEdu}_{-i,j,k} + Z'_{i,j,k} \Gamma + \delta_k + \epsilon_{i,j,k} \quad (2)$$

With the inclusion of mechanism variables, the outcome equation is then augmented as follows:

$$Y_{i,j,k} = \zeta_0 + \zeta_1 \overline{MoEdu}_{-i,j,k} + \sum_c \gamma^c m_{i,j,k}^c + Z'_{i,j,k} \Gamma + \delta_k + \epsilon_{i,j,k} \quad (3)$$

The result of this augmented version is already shown in Column 3 of Table 9. To further evaluate the explanatory power of each mechanism c , we compute the percent of explained variation by $\gamma^c \alpha_1^c / \hat{\beta}_1$ in Table 10. It is not surprising that the conventional peer effect channel in total contributes to about one-third of peer maternal spillover. Each of

the teacher channels constitutes about 2% to 6% of the spillover. Our newly purposed channel of the adjustment in the responsive parenting style explains 4.4% of the spillover generated by peer maternal education. It is indeed as important as the gender peer effect channel. The parenting channel is also at least two-third of the significance of most of the other conventional medicating factors. Therefore, parental adjustment is a non-negligible mechanism.

Table 10: Parental Adjustment Is A Non-negligible Channel

| Channels | % variation explained: |
|-------------------------|------------------------|
| peer (female) | 4.748 |
| peer (migrant) | 8.064 |
| peer (repeater) | 14.56 |
| peer (persistence) | 5.298 |
| teacher (responsible) | 2.149 |
| teacher (patient) | 6.443 |
| headteacher (praise) | 6.228 |
| parent (responsiveness) | 4.419 |
| parent (demandingness) | 0.312 |
| unexplained | 47.778 |

Note: We follow the approach by [Gong, Lu and Song \(2019\)](#) to examine the relative explanatory power of each mechanism.

6 Heterogeneous Effects

In this section, we examine the heterogeneity behind the peer maternal spillover by student characteristics. In the empirical estimation, we interact peer maternal education with three student/family characteristics. In addition to student’s maternal education, we also look at repeater and migrant status. A repeater is a student who has grade retention in primary school, which is used as an indicator for low-achieving students ([Xu, Zhang and Zhou, 2020](#)). A migrant student is a student who is not a local resident, who usually is associated with a disadvantaged socioeconomic status in China.

We divide Table 11 into three panels corresponding to the three characteristics. In each panel, Column 1 first assesses if the test score of students of a particular background

responds differently to peer maternal spillover and the rest of the columns explore possible mechanisms, namely different types of parental adjustment.

In Panel A of Table 11, we find that the spillover effect of peer maternal education does not vary with the educational background of the student's own mother. Parental response in the rest of the columns neither varies with the mother's education. In contrast, as shown by the interaction terms in Column 1 of Panel B and C, the magnitude of non-repeaters and non-migrant students is significantly stronger. This implies that the spillover of peer maternal education on test scores significantly varies with student's repeater and migrant status. The results in Panel B and C suggest that there exists a complementary relationship between peer maternal education and higher-achievers/non-migrant status.

In Column 2, we find out that parental reaction is a vital link behind. Parents of non-repeaters and non-migrant students invest significantly more in the homework guide when more mothers of classmates have a college degree. We also observe a higher parental investment on money for non-repeaters in Column 5 but with a marginally significant coefficient.

In Table 12, we explore teacher response as an alternative mechanism behind the heterogeneity experienced by repeaters and migrant students. However, as shown in Panel B and C, we do not observe a consistent and meaningful pattern about the interaction terms. The coefficients are neither statistically significant.

Table 11: Heterogeneous Effects behind Peer Maternal Spillover

| | Academic Outcome | | Mechanism: Parental Investment | | | | |
|--|---------------------|----------------------|--------------------------------|---------------------|---------------------|----------------------|---------------------|
| | Test score | Homework guide | Time | Tutoring | Tutoring fee | Responsive parenting | Demanding parenting |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Panel A: Own mother's education | | | | | | | |
| Peer maternal education * Maternal education | 0.000 (0.193) | -0.078 (0.391) | 1.372 (1.506) | -0.319* (0.168) | -2.435 (1.513) | -0.118 (0.209) | -0.235 (0.172) |
| Peer maternal education | 0.909** (0.432) | -0.456 (0.400) | -0.167 (2.820) | 0.109 (0.186) | 0.724 (1.328) | 0.627** (0.254) | 0.033 (0.246) |
| Maternal education | 0.259*** (0.069) | 0.248** (0.096) | -0.554 (0.467) | 0.117** (0.046) | 0.913** (0.387) | 0.180*** (0.068) | 0.048 (0.057) |
| Panel B: Repeated in primary school (i.e. Non-repeater) | | | | | | | |
| Peer maternal education * Non-repeater | 2.341*** (0.735) | 1.741** (0.526) | -0.662 (4.251) | 0.433 (0.269) | 3.803* (2.077) | 0.571 (0.392) | -0.354 (0.404) |
| Peer maternal education | -1.334 (0.915) | -2.096*** (0.621) | -0.662 (4.251) | -0.359 (0.294) | -3.315 (2.273) | 0.061 (0.483) | 0.332 (0.440) |
| Non-repeater | 0.106** (0.053) | 0.052 (0.042) | 0.057 (0.385) | 0.010 (0.019) | 0.028 (0.134) | 0.039 (0.037) | 0.076** (0.031) |
| Panel C: Migrant Status | | | | | | | |
| Peer maternal education * Non-migrant student | 0.476** (0.223) | 0.824*** (0.265) | -1.264 (1.786) | -0.157 (0.101) | -1.157 (0.897) | 0.017 (0.164) | 0.074 (0.145) |
| Peer maternal education | 0.479 (0.469) | -1.212*** (0.463) | 1.211 (3.071) | 0.195 (0.217) | 1.347 (1.551) | 0.591** (0.285) | -0.074 (0.277) |
| Non-migrant student | -0.107* (0.062) | -0.073* (0.044) | 0.080 (0.325) | 0.049*** (0.015) | 0.399*** (0.124) | 0.021 (0.039) | -0.038 (0.038) |
| Observations | 7,053 | 4,556 | 7,248 | 6,980 | 6,722 | 6,876 | 6,807 |

Note. 'Peer maternal education' refers to the leave-one-out average college attainment of classmates mothers. All regressions include student controls, teacher controls, peer controls, and school-grade fixed effects, in which the controls are the same with previous analyses. Robust standard errors clustered at school-grade level are in brackets. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Source. China Education Panel Survey 2013-14.

Table 12: Heterogeneous Effects behind Peer Maternal Spillover (Continued)

| | Mechanism: Teacher Respond | | | |
|--|------------------------------|-----------------------------|---|--|
| | “Teacher responsible” (1) | is “Teacher patient” (2) | is “Headteacher always praises me” (3) | “Headteacher always criticize me” (4) |
| Panel A: Own mother’s education | | | | |
| Peer maternal education * Maternal education | -0.261 (0.190) | -0.168 (0.182) | -0.229 (0.254) | -0.000 (0.197) |
| Peer maternal education | 0.781** (0.300) | 0.693** (0.293) | 0.672** (0.314) | -0.241 (0.346) |
| Maternal education | 0.103* (0.060) | 0.099* (0.059) | 0.222*** (0.067) | -0.070 (0.058) |
| Panel B: Repeated in primary school (i.e. Non-repeater) | | | | |
| Peer maternal education * Non-repeater | -0.358 (0.377) | -0.673 (0.446) | 0.193 (0.476) | -0.311 (0.487) |
| Peer maternal education | 1.079** (0.446) | 1.308** (0.506) | 0.447 (0.521) | 0.056 (0.557) |
| Non-repeater | 0.061 (0.039) | 0.080* (0.046) | 0.013 (0.041) | -0.027 (0.046) |
| Panel C: Migrant Status | | | | |
| Peer maternal education * Non-migrant student | -0.118 (0.173) | -0.189 (0.170) | -0.127 (0.20) | 0.043 (0.196) |
| Peer maternal education | 0.843** (0.343) | 0.835** (0.324) | 0.746* (0.383) | -0.280 (0.383) |
| Non-migrant student | 0.019 (0.040) | 0.030 (0.039) | 0.051 (0.040) | -0.000 (0.039) |
| Observations | 6,983 | 6,971 | 7,201 | 7,206 |

Note. ‘Peer maternal education’ refers to the leave-one-out average college attainment of classmates mothers. All regressions include student controls, teacher controls, peer controls, and school-grade fixed effects, in which the controls are the same with previous analyses. Robust standard errors clustered at school-grade level are in brackets.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Source. China Education Panel Survey 2013-14.

7 Conclusion

In many peer effect studies, parental education of peers is often a nuisance parameter. Mostly it is used to proxy for peer influence, for example, the effect of having higher-ability peers defined by mother's or father's education. Besides just being an alternative measure of peer's type, the parent of peer indeed is another non-negligible source of social influences. The effect from peers' parents on young people may go through their own child or through other unexplored channels.

We take the opportunity of the institutional setting in China that students are randomly assigned to classes in their first year of middle school. We are able to establish a causal interpretation of peer maternal education on a student test score. The mechanisms we uncover here involve the reaction by parents and teachers when they take into account other societal forces. Our finding here reaffirms the perspective taken by similar studies that treat parents of others as separate entities who generate social influences.

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Appendix to:
“Understanding spillover of peer parental education:
Randomization evidence and mechanisms”

Bobby W. Chung & Jian Zou

June, 2020

Figure A1: Histogram of class-level fathers' education

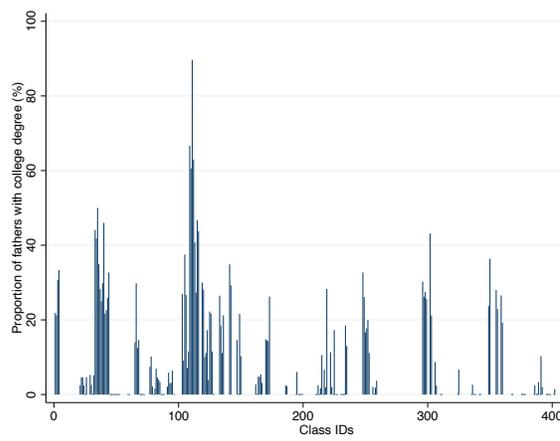


Figure 1a. Raw Distribution

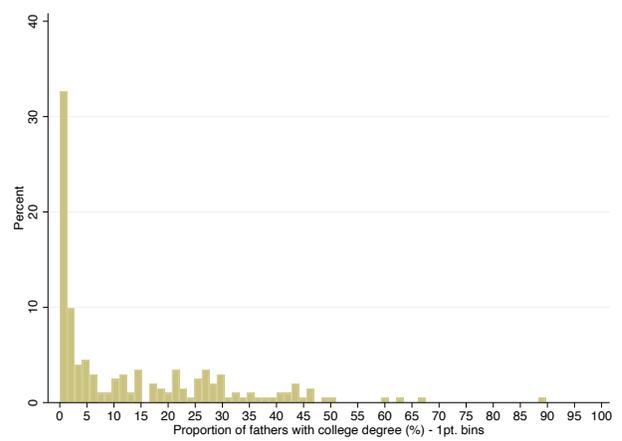


Figure 1b. Histogram of fathers' education

Note. Figure 1a plots the proportion of fathers with college degree across the classes, while Figure 1b plots the histogram of proportion of fathers with college degree (shown in 1 percentage-point bins). The proportion of fathers with college degree ranges from 0 to 89.66 percentage points.

Figure A2: Histogram of between-class difference

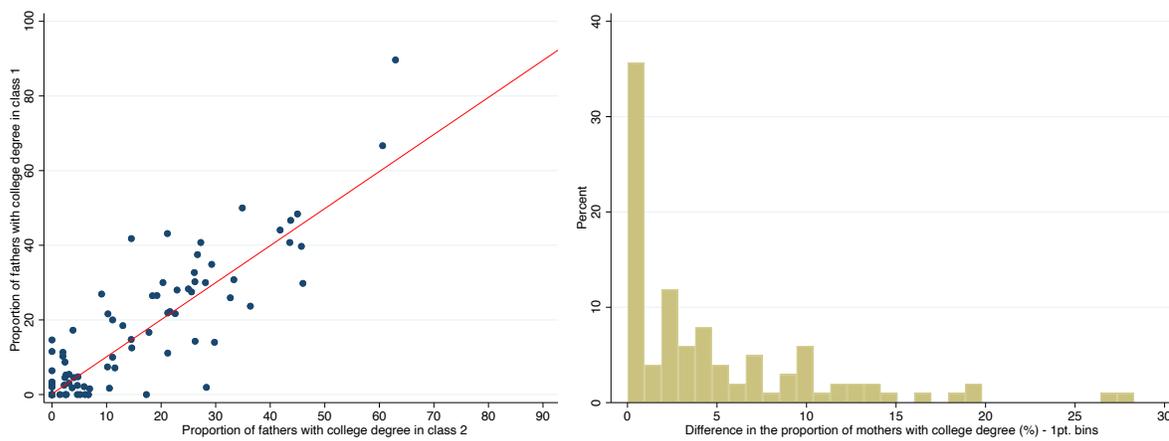


Figure 1a. of Within-grade correlation

Figure 1b. Histogram of difference in fathers' education in two classes within each school-grade

Note. Figure 2a plots the proportion of fathers with college degree across two classes within each school-grade, while Figure 1b plots the histogram of differences of proportion of fathers with college degree in two classes within each school-grade (shown in 1 percentage-point bins). The within school-grade differences of proportion of fathers with college degree ranges from 0 to 27.25 percentage points.

Table A1: Balancing Tests for Head Teacher Assignment

| | The proportion of peers' X in class | |
|---------------------------------|--|--|
| | (1) X = Mothers with college degree | (2) X = Fathers with college degree |
| Head teacher Age | 0.003 (0.004) | -0.001 (0.005) |
| Head teacher Female | 0.025 (0.022) | 0.021 (0.021) |
| Marriage status | -0.020 (0.029) | -0.023 (0.025) |
| Have a college degree | -0.021 (0.020) | -0.025 (0.018) |
| Teaching experience in years | -0.004 (0.004) | 0.000 (0.004) |
| Graduated from a normal college | -0.006 (0.033) | -0.019 (0.031) |
| Have a teacher certificate | 0.007 (0.023) | -0.002 (0.030) |
| School-Grade FE | yes | yes |
| Observations | 198 | 198 |

Note. Data are collapsed to class level for balancing analysis, where each observation represents one head teacher from one class. Each column shows a regression which regress the proportion of classmates' mothers or fathers having a college degree on head teachers' characteristics, controlling for school-grade fixed effects. Robust standard errors clustered at the school-grade level are in brackets. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A2: Impacts of Peer Mothers' Education on Academic Outcomes: By Subject

| | Std. total test score | | |
|-------------------------|-----------------------|---------------------|---------------------|
| | (1) Chinese | (2) Math | (3) English |
| Peer maternal education | 0.969*** (0.367) | 0.892** (0.434) | 0.613 (0.529) |
| Maternal Education | 0.193*** (0.038) | 0.245*** (0.035) | 0.254*** (0.033) |
| School-Grade FE | yes | yes | yes |
| Student Controls | yes | yes | yes |
| Peer Controls | yes | yes | yes |
| Teacher Controls | yes | yes | yes |
| Adjusted R-squared | 0.114 | 0.044 | 0.113 |
| Observations | 7,062 | 7,063 | 7,065 |

Note. The dependent variables are three subject exam scores standardized by grade and school, to obtain a zero mean and one standard deviation. 'Peer Mothers' College Degree' measures the proportion of peer mothers having college degree or above in the classroom, while 'Parental College Degree' is a dummy indicating whether the student have father or mother who has college degree or above. The student controls include age, gender, minority, hukou status, migrant status, whether from one child family, whether attended kindergarten, age attending primary school, persistence and non-cognitive measure at Grade 6, whether skip grade and whether repeat grade in primary school, and parental education attainment. The teacher controls include headteacher's age, gender, teaching experience, and dummy variables indicating marital status, had professional job title, had college degree or above, and graduated from a normal college. Peer controls include the classroom proportion of female, migrant and low-ability peer, and peers' persistence. Robust standard errors clustered at school-grade level are in brackets. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A3: Mechanism: Parenting Style - Responsiveness Factors

| | Dependent variable: Responsiveness | | | | | |
|-------------------------|------------------------------------|---------------------|--------------------|---------------------|---------------------|---------------------|
| | (1) I | (2) II | (3) III | (4) IV | (5) V | (6) Average |
| Peer maternal education | 0.571** (0.275) | 0.615* (0.326) | 0.648* (0.361) | 0.647** (0.265) | 0.555** (0.255) | 0.751** (0.305) |
| Maternal Education | 0.229*** (0.037) | 0.163*** (0.043) | 0.100** (0.045) | 0.121*** (0.038) | 0.146*** (0.040) | 0.188*** (0.043) |
| School-Grade FE | yes | yes | yes | yes | yes | yes |
| Student controls | yes | yes | yes | yes | yes | yes |
| Peer controls | yes | yes | yes | yes | yes | yes |
| Teacher controls | yes | yes | yes | yes | yes | yes |
| Adjusted R-squared | 0.139 | 0.110 | 0.083 | 0.131 | 0.120 | 0.168 |
| Observations | 6,876 | 6,876 | 6,876 | 6,876 | 6,876 | 6,876 |

Note. The dependent variables are five factor items in the parents questionnaire on calculate the responsiveness parenting. Details of question items can be found in the text. ‘Peer Mothers’ College Degree’ measures the proportion of peer mothers having college degree or above in the classroom, while ‘Parental College Degree’ is a dummy indicating whether the student have father or mother who has college degree or above. The student controls include age, gender, minority, hukou status, migrant status, whether from one child family, whether attended kindergarten, age attending primary school, persistence and non-cognitive measure at Grade 6, whether skip grade and whether repeat grade in primary school, and parental education attainment. The teacher controls include headteacher’s age, gender, teaching experience, and dummy variables indicating marital status, had professional job title, had college degree or above, and graduated from a normal college. Peer controls include the classroom proportion of female, migrant and low-ability peer, and peers’ persistence. Robust standard errors clustered at school-grade level are in brackets. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$..

Table A4: Mechanism: Parenting Style - Demandingness Factors

| | Dependent variable: Demandingness | | | | | | | | |
|-------------------------|-----------------------------------|-------------------|-------------------|-------------------|------------------|-------------------|-------------------|------------------|-------------------|
| | (1) I | (2) II | (3) III | (4) IV | (5) V | (6) VI | (7) VII | (8) VIII | (9) Average |
| Peer maternal education | -0.370 (0.401) | 0.418 (0.342) | -0.189 (0.387) | -0.041 (0.361) | 0.284 (0.352) | -0.105 (0.245) | -0.097 (0.220) | 0.099 (0.266) | -0.011 (0.367) |
| Maternal Education | 0.002 (0.043) | -0.014 (0.041) | -0.043 (0.047) | -0.038 (0.040) | 0.003 (0.046) | 0.003 (0.027) | -0.022 (0.040) | 0.043 (0.035) | -0.012 (0.045) |
| School-Grade FE | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| Student controls | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| Peer controls | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| Teacher controls | yes | yes | yes | yes | yes | yes | yes | yes | yes |
| Adjusted R-squared | 0.084 | 0.067 | 0.035 | 0.053 | 0.053 | 0.068 | 0.061 | 0.058 | 0.094 |
| Observations | 6,807 | 6,807 | 6,807 | 6,807 | 6,807 | 6,807 | 6,807 | 6,807 | 6,807 |

Note. The dependent variables are eight factor items in the parents questionnaire on calculate the demandingness parenting. Details of question items can be found in the text. ‘Peer Mothers’ College Degree’ measures the proportion of peer mothers having college degree or above in the classroom, while ‘Parental College Degree’ is a dummy indicating whether the student have father or mother who has college degree or above. The student controls include age, gender, minority, hukou status, migrant status, whether from one child family, whether attended kindergarten, age attending primary school, persistence and non-cognitive measure at Grade 6, whether skip grade and whether repeat grade in primary school, and parental education attainment. The teacher controls include headteacher’s age, gender, teaching experience, and dummy variables indicating marital status, had professional job title, had college degree or above, and graduated from a normal college. Peer controls include the classroom proportion of female, migrant and low-ability peer, and peers’ persistence. Robust standard errors clustered at school-grade level are in brackets. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.