

The Company You Keep:

Peer Effects of Early Childhood Education on Learning and Mental Health in Early Adolescence

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Version: September 2026

Abstract

Standard evaluations of early childhood education measure returns to the individual attendee, ignoring the possibility that skills acquired in early childhood propagate to peers through sustained social interaction. If such spillovers exist, the social returns to early childhood investment are systematically underestimated. We test this hypothesis using nationally representative panel data on middle-school students in China, exploiting random classroom assignment to estimate the causal effect of exposure to kindergarten-attending peers on mental health, social adjustment, and academic outcomes. Effects are negligible after three to six months of peer exposure. After fourteen or more months, a ten-percentage-point increase in peer kindergarten share improves non-cognitive outcomes by 0.074 standard deviations and academic achievement by 0.072 standard deviations. Drawing on the technology of skill formation, we interpret these duration-dependent results as evidence that behavioral norms and socio-emotional competencies require sustained peer interaction to propagate. Effects are concentrated among disadvantaged students, suggesting that deliberate classroom integration represents a low-cost lever for reducing socioeconomic disparities, especially in non-cognitive skill formation.

Key Words: Kindergarten attendance, positive spillovers, cognitive and non-cognitive measures, mental health, middle-school, China

JEL Codes: I10, I21, I24, I26, J13, J24

Declaration of Interest: None

*We thank Feng Hu, Kirabo Jackson, and John List for detailed comments on previous drafts. We are also indebted to seminar and conference participants at Bentley University, International Association of Applied Econometrics 2023, Southern Economic Association 2023, the Indian Institute of Management-Kolkata and the Australian Development Economics Workshop 2023 for comments and suggestions. The usual disclaimer applies. [†]Associate Professor, Business

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1. Introduction

A large body of evidence documents that early childhood education (ECE) generates lasting benefits for participants, improving cognitive development, socio-emotional outcomes, and long-run labor market performance (Heckman et al. 2013; García et al. 2020; Behrman et al. 2024). The social returns to ECE — the extent to which skills acquired in early childhood spill over to benefit peers in later schooling years — remain, however, poorly understood. This gap matters for two distinct reasons. First, if ECE generates positive peer externalities, standard estimates of its returns will understate its true social value. Second, and more practically, understanding whether and how peer spillovers from ECE operate can inform classroom composition policies that are administratively tractable without requiring additional investment in ECE infrastructure — a consideration of direct relevance in low and middle-income countries where ECE enrollment has expanded rapidly but unevenly.

This paper addresses these questions by separately estimating short-run and medium-run peer effects using a panel design that follows the same students and the same classroom peers at two distinct exposure horizons. Our central question is: what are the consequences for a student's non-cognitive and academic outcomes of being randomly placed in a middle-school classroom with a higher share of peers who attended kindergarten? We focus on non-cognitive outcomes — specifically mental health and social adjustment — as the primary contribution, for reasons grounded in the economics of skill formation. Cunha and Heckman (2007) establish that non-cognitive skill formation is characterized by self-productivity and dynamic complementarity: skills accumulated in prior periods raise the efficiency of subsequent investments, and the returns to a given peer environment grow as students interact with that environment over time. The key implication for our setting is straightforward: non-cognitive competencies such as behavioral self-regulation, emotional stability, and social adjustment are internalized gradually through repeated peer interaction, not transmitted instantaneously as academic knowledge might be through direct instruction or observation (Cunha and Heckman 2007; Heckman et al. 2013). A student placed alongside kindergarten-attending peers therefore cannot be expected to show non-cognitive gains after a short period of exposure (e.g., three to six months) — the interaction has simply not lasted long enough for behavioral norms to consolidate. Gains should emerge, and grow, with sustained exposure. We test this prediction using data.

We draw on two waves of the China Education Panel Survey (CEPS), a nationally representative longitudinal dataset on junior secondary students. A distinctive feature of our design is that we observe the same students and the same classroom peers at two points in time: after approximately three to six months of peer exposure in Grade 7, and after fourteen to eighteen

months of exposure in Grade 8. This panel structure allows us to test directly whether peer spillovers are duration-dependent. The identification strategy exploits random assignment of students to classrooms within schools, a practice mandated by China's Compulsory Education Law and confirmed by school principals and homeroom teachers in the CEPS administrator survey. We restrict the sample to schools where both the headmaster and the homeroom teacher confirm random assignment in Grade 7 and further restrict the medium-run sample to schools that did not reassign students in Grade 8, ensuring peer groups remain stable throughout the exposure window.

Our main findings are as follows. After three to six months of peer exposure, we find no statistically significant effect of peer kindergarten share on non-cognitive or academic outcomes — a result we attribute to insufficient duration of peer interaction for behavioral norms to consolidate. After fourteen to eighteen months of exposure, however, a ten-percentage-point increase in peer kindergarten share improves non-cognitive outcomes by 7.4 percent of a standard deviation, social adjustment by 6.9 percent of a standard deviation, and academic achievement by 7.2 percent of a standard deviation. This implies that moving a student from a classroom at the tenth percentile of peer kindergarten share (approximately 30 percent) to the ninetieth percentile (approximately 80 percent) would improve non-cognitive outcomes by approximately 0.37 standard deviations. The mental health effect alone amounts to approximately 14.8 percent of the direct effect of own kindergarten attendance on non-cognitive skills, representing a non-trivial positive externality. These effect sizes are statistically significant and place the academic gains at the 85th percentile of the distribution of effect sizes across educational interventions in low- and middle-income countries documented by Evans and Yuan (2022).

A central issue is whether the estimated effects reflect the causal impact of peer kindergarten attendance, rather than selection into classrooms. We begin by providing direct evidence that classroom composition is as good as randomly assigned within schools. Conditional on school fixed effects, we find that peer kindergarten share is uncorrelated with a rich set of predetermined student, family, and teacher characteristics, with an F-test for their joint significance yielding a p -value of 0.87. School fixed effects absorb time-invariant school-level confounders, so our estimates are identified from variation in peer kindergarten shares across classrooms within the same school. Nevertheless, we acknowledge that our design does not isolate the effect of peer kindergarten attendance from the correlated bundle of peer characteristics that accompany it. For example, students who attended kindergarten may differ from non-attendees along several observable dimensions: they are more likely to be only children, to have more educated parents, and less likely to have repeated a grade in primary school. To assess the extent to which unobserved peer characteristics drive this estimate, we augment the main specification sequentially with peer-level controls that are plausibly determined prior to kindergarten enrollment — specifically, the share of peers from low-income households, peers with rural hukou, and peers whose mothers and fathers completed at least high school. The peer kindergarten coefficient remains statistically significant and precisely estimated

across all augmented specifications for both non-cognitive and academic outcomes, and the direction and significance of effects are unchanged throughout, suggesting limited scope for unobserved peer characteristics to drive our findings in any substantive way.

We document heterogeneity across student subgroups. Peer kindergarten effects on non-cognitive outcomes are concentrated among disadvantaged students. Children of mothers without a college education experience gains in mental health and social adjustment that are statistically distinct from those of children with college-educated mothers at the one percent level, and rural students benefit more than their urban counterparts across all outcomes. These patterns suggest that peer kindergarten partially substitutes for parenting quality and human capital that disadvantaged households are less able to provide (Yamaguchi et al. 2018), and that mixed-composition classrooms may function as an equalizing mechanism in settings characterized by uneven ECE access. We investigate mechanisms using a decomposition analysis following Heckman et al. (2013) and Gelbach (2016). For non-cognitive outcomes, peer-to-peer channels dominate: improvements in classroom atmosphere, peer behavioral norms, and students' own socio-emotional development account for the majority of the explained effect. For academic outcomes, changes in students' own effort and homework investment are the primary mediating channel. Crucially, we find no evidence that teachers alter their effort, working hours, or pedagogical approach in response to classroom composition, strengthening the interpretation that effects operate through peer interaction rather than instructional changes.

Our study is most closely related to Zhang et al. (2023), who use Wave I of the CEPS to examine whether exposure to preschool-attending classmates improves cognitive and mental health outcomes among middle-school students in China. We build on and depart from their work in three specific ways. First, whereas Zhang et al. (2023) use only cross-sectional Wave I data capturing three to six months of peer exposure, we exploit the panel structure of the CEPS to follow the same students into Grade 8. This allows us to test whether peer effects strengthen with sustained interaction. The null result after three to six months is not an incidental finding but the specific prediction of the skill formation framework: behavioral self-regulation and socio-emotional competencies are internalized through repeated interaction over time, and three to six months is insufficient for such norms to consolidate. The emergence of significant effects after fourteen to eighteen months constitutes a direct empirical test of this duration-dependence, and the ability to conduct this test within the same sample — observing the same students and the same classmates at both horizons — is what distinguishes our design from cross-sectional work. Second, Zhang et al. (2023) include both Grade 7 and Grade 9 students without restricting the analysis to schools that maintained stable classroom rosters across waves, meaning their peer groups may not represent a consistent, constant longer-term social environment. We restrict our medium-run sample to schools that did not reassign students in Grade 8, ensuring that estimated medium-term effects reflect spillovers operating within intact peer groups. Third, and most substantively, Zhang et al. (2023) focus on cognitive outcomes and a narrow set of mental health

indicators. We prioritize mental health and social adjustment as primary outcomes, document their duration-dependence, and connect this temporal pattern explicitly to the technology of skill formation — a theoretical contribution that is absent from prior work in this literature.

Our paper makes four contributions. First, we provide causal evidence that non-cognitive skills acquired in early childhood generate peer spillovers that shape the mental health of middle-school classmates. Prior work on ECE externalities has focused predominantly on cognitive outcomes in early schooling (Neidell and Waldfogel 2010; Zhang et al. 2023), while the broader peer effects literature has examined non-cognitive spillovers without connecting them to early childhood investments (Golsteyn, Non, and Zölitz 2021). We bridge these two literatures and demonstrate that peer kindergarten spillovers on mental health and social adjustment are absent after three to six months, but emerge and grow meaningfully after fourteen to eighteen months of sustained classroom interaction — a duration-dependence that we interpret through the technology of skill formation (Cunha and Heckman 2007), and that carries direct implications for policy.

Second, we contribute evidence to the literature on the persistence and fade-out of ECE effects. A growing body of work documents that (one's own) cognitive gains from early childhood programs diminish by elementary or middle school (Burchinal et al. 2024; Whitaker et al. 2026), raising questions about the long-run value of ECE investment. Our findings identify peer composition as a mechanism through which early childhood investments continue to shape adolescent non-cognitive outcomes even as individual cognitive gains dissipate — complementing and extending List and Uchida (2024) and Botvin et al. (2024), who show that cognitive fade-out is attenuated when children are surrounded by peers who also received early childhood education. We accomplish this by demonstrating that analogous dynamics operate for non-cognitive outcomes and persist into early adolescence.

Third, we contribute to the literature on socioeconomic disparities in skill formation by documenting that peer kindergarten spillovers are concentrated among disadvantaged students and appear when students have spent adequate time with their peers. Children whose mothers did not complete college experience gain in mental health and social adjustment significantly more than children with college-educated mothers; rural students similarly benefit more than their urban counterparts across all outcomes. This finding contrasts with evidence that exposure to low-achieving or economically deprived classmates generates negative spillovers (Xu et al. 2022; Huang et al. 2025), and highlights the potential for the early childhood human capital of peers to function as an equalizing mechanism — suggesting that deliberate classroom integration of kindergarten and non-kindergarten attendees may help to reduce gaps in non-cognitive skill formation that are otherwise difficult to address.

Fourth, we contribute to the literature on ECE in middle-income countries by providing externally valid evidence from a large-scale, nationally representative setting. Prior evaluations of ECE externalities have relied on small samples or local experiments with limited generalizability (List and Uchida 2024; Botvin et al. 2024). Our analysis draws on 48 schools

across 28 counties in China, with a sampling frame spanning diverse socioeconomic conditions, urbanization levels, and institutional capacities. Applying the SANS framework (List 2020), we argue that the mechanisms we identify — operating through classroom composition, behavioral norm transmission, and socio-emotional skill development — are not context-specific and are likely operative across middle-income settings where ECE enrollment has expanded rapidly but unevenly, with direct implications for how ECE programs are designed, targeted, and evaluated.

The remainder of the paper proceeds as follows. Section I describes the institutional context of kindergarten education in China. Section II describes the data and key variables. Section III presents the empirical strategy and identification tests. Section IV reports the main results for academic and non-cognitive outcomes, including an analysis of heterogeneous effects across student subgroups. Section V investigates mechanisms. Section VI presents robustness checks. Section VII concludes with policy implications and directions for future research.

2. Context: Kindergarten in China

The educational system in China consists of nine years of mandatory education, encompassing six years of primary education and three years of junior secondary education. China's kindergarten education (part of preschool education) serves children roughly 3 to 6 years old, typically in the three years prior to first grade in primary school. Programs are usually full-day (often approximately 8 a.m. to 5 p.m.) and may span one to three years depending on local offerings. Children are generally grouped by age, and daily schedules include multiple class periods (15–40 minutes each) interspersed with meals, naps, and play. Kindergarten is not compulsory and not free, unlike the nine years of primary and junior secondary schooling.

During the period when the students in our study attended kindergarten (early to mid-2000s), preschool education in China was undergoing gradual expansion but still varied substantially across regions and socioeconomic groups. The early 2000s marked a critical transitional period for early childhood education (ECE) policy in China. In 2003, the State Council issued the “Guiding Opinions on the Reform and Development of Early Childhood Education”,¹ which established several key targets for the 2003–2007 period. These include (1) achieving a national gross enrollment rate of 55 percent for three-year preschool education; (2) reaching 80 percent enrollment for one-year preschool education; (3) attaining 90 percent enrollment in urban and economically developed areas for three-year preschool education; and (4) setting differential targets of 50 percent and 35 percent for counties with and without nine-year compulsory education, respectively. The policy also explicitly encouraged the development of privately-run kindergartens as a major component of the ECE system, recognizing that public provision alone could not meet the growing demand.

Following the implementation of this policy, the number of kindergartens grew steadily from approximately 111,700 in 2002 to about 124,400 in 2005. Concurrently, the private sector expanded rapidly, with the proportion of private kindergartens increasing from 43.3 percent in 2002 to 55.3 percent in 2005.² Despite this growth, affordable and high-quality public

kindergartens remain scarce in the country, while costly private alternatives are more accessible (Hong and Chen 2017). Nonetheless, preschool education has gained significant popularity with economic prosperity. Statistics indicate that the gross enrollment rate for three-year preschool education for the cohort born in 2001 was approximately 36 percent; by the 2009 cohort, the rate had risen to 50 percent. By 2014, the attendance rate had exceeded 70 percent (Li et al. 2016). Throughout this period, enrollment varied tremendously across provinces and between urban and rural areas, with rural enrollment rates lagging substantially behind their urban counterparts.

During the early to mid-2000s, China's kindergarten teacher workforce was characterized by severe shortages and regional disparities. Official regulations stipulated a pupil-teacher ratio of 6:1 to 7:1. However, actual conditions fell far short of this standard. According to UNESCO (2007), China's average kindergarten pupil-teacher ratio was 30:1 in 2005, with rural areas reaching as high as 36:1. In 2005, the Ministry of Education issued a critical policy document, which mandated that provincial education authorities conduct special evaluations of teacher training institutions and ordered that institutions failing to meet basic standards must stop enrolling teacher-training students starting in 2006. Later, in 2015, the Chinese government enacted a law for kindergarten operations, requiring adherence to rigorous personnel and qualification standards to guarantee high-quality early childhood education. Kindergarten educators are required to have a valid early childhood education certificate, while health and hygiene professionals must possess relevant qualifications, including a "Physician's Practice Certificate" for physicians, and a "Nurse's Practice Certificate" for nurses. Overall, the regulatory trend is toward professionalization – elevating the status of early education teachers and enforcing standards for curriculum, safety, and child-to-staff ratios – in line with the government's goal of assuring quality across all early education settings.

Kindergarten education in China facilitates children's transition from home to primary school by promoting their scholastic and socio-emotional development. National guidelines (e.g. *the Kindergarten Education Guidelines* issued by the Ministry of Education) promote a balanced curriculum covering health, language, social, science, and arts domains, and encourage play-based and inquiry-based learning. In practice, many kindergartens incorporate songs, games, hands-on activities and free play time to foster creativity and joy in learning. At the same time, there is a longstanding cultural emphasis on academic readiness and behavioral discipline. China's ECE philosophy was heavily influenced by the Soviet model during the mid-20th century, and elements of teacher-directed whole-class instruction and emphasis on order remain pronounced. Teachers often stress conformity, respect for authority, self-control, and group harmony, consistent with Confucian and collectivist values (Bullough and Palaiologou 2019). This can translate to more structured routines and an academic focus (e.g. practicing Chinese characters or arithmetic) at the preschool stage.

There is no single national curriculum; however, Ministry of Education (MOE) guidelines ensure core developmental domains are covered. Most kindergartens teach basic literacy and numeracy (e.g. simple Chinese characters and introductory math concepts) alongside art, music, and physical activities. In language classes, children are instructed in fundamental Chinese characters

and pinyin, the Romanized representation of Chinese characters according to their sound, to equip them for primary education. Furthermore, youngsters get acquainted with English by learning basic vocabulary, including typical greetings and the names of fruits. In mathematics classrooms, children acquire foundational knowledge of numerals and addition. Overall, China's kindergarten is a hybrid pedagogy: classrooms aim to be cheerful and stimulating, yet teachers carefully manage activities to meet developmental goals and prepare children for the academic rigor of primary school.

Even in the early to mid-2000s, promoting children's social and emotional development was recognized as a core objective of Chinese kindergarten education. Many kindergartens explicitly incorporate social-emotional learning into their curricula through group play, stories, and teacher-guided discussions aimed at fostering skills like sharing, empathy, self-confidence, and emotional regulation (Zong et al. 2024). Kindergarten classrooms often organize children into small groups for collaborative activities, free play centers, and projects that encourage communication and self-expression, counterbalancing the traditional emphasis on listening and obedience. This trend aligns with international evidence that early social and emotional learning support yields benefits for academic readiness and well-being. Overall, the objective of KG education in China is to equip children to face future academic obstacles and interpersonal relationships with assurance and fortitude.

3. Data

Our analysis draws on two waves of the China Education Panel Survey (CEPS), conducted between 2013 and 2015. The CEPS is a nationally representative survey focusing on junior secondary school students. The first wave, administered during the 2013–2014 academic year, covered 17 counties in the Fall of 2013 and an additional 11 counties in the Spring of 2014. The survey employed a stratified, multistage sampling design: 28 counties were first selected from 2870 counties/districts in the country, followed by four middle-schools per county, and then two classrooms each from Grade 7 and Grade 9 within each school. All students in the sampled classrooms were surveyed, yielding a baseline sample of 19,958 students across 438 classrooms in 112 schools. Of these, 10,279 were in Grade 7 and 9,208 in Grade 9. The second wave, conducted in the 2014–2015 academic year, successfully tracked the Grade 7 cohort into Grade 8, achieving full panel follow-up for this group.

Our analysis focuses on the cohort of Grade 7 students surveyed in the first wave of the CEPS, who were subsequently followed into Grade 8 in the second wave. We use data from wave one to estimate the short-term effects of peers' kindergarten (KG) attendance, capturing interactions that occurred within the first three to six months of classroom assignment. To assess the impact of more sustained peer exposure, we use data from wave two, which reflects student outcomes after approximately 14 to 18 months of interaction with the same set of classmates. This distinction between short-term and medium-term peer effects enables us to capture the cumulative nature of peer spillovers and represents a key departure from Zhang et al. (2023), whose analysis relies primarily on wave one data.

The CEPS data provide rich information on students' family backgrounds, cognitive and non-cognitive abilities, and classroom environments, based on linked surveys administered to students, parents, teachers, and school administrators. A critical component of our identification strategy relies on the question in the administrator survey that asks whether students were randomly assigned to classrooms. We restrict the sample to schools where the headmaster confirms random assignment in Grade 7 and the homeroom teacher reports no subsequent reassignment based on test scores or other criteria during that grade. To ensure within-school variation, we further exclude schools with only one class per grade. These restrictions yield a baseline sample of Grade 7 students who were randomly assigned to classrooms. For our short-run analysis, we examine this cohort's outcomes in Grade 7, using final analysis samples of 4,427 and 4,171 students for academic and non-cognitive outcomes, respectively, after accounting for missing values in covariates and outcome measures. For the medium-run analysis, we further restrict the sample to schools that did not reassign students in Grade 8, thereby ensuring stable peer groups over time and further distinguishing our approach from Zhang et al. (2023). The final analysis samples (for the medium run effects) consist of 3,634 and 3,473 students for academic and non-cognitive outcomes, respectively. The sample selection methodology bolsters the credibility of our findings by alleviating concerns about endogenous sorting of students based on observable or unobservable characteristics, while ensuring sufficient interaction time among students for peer dynamics to take shape. This is akin to the strategy adopted by other peer effects studies including Sacerdote (2001); Carrell et al (2009); Gong et al (2021); Xu et al. (2022); and Chen and Hu (2024).

A. Definition of key variables

Our analysis focuses on two primary outcome variables: academic performance and non-cognitive abilities. Academic performance is measured using student test scores in three core subjects—Chinese, mathematics, and English. The China Education Panel Survey (CEPS) provides standardized test scores for midterm examinations administered during the Fall semester, with each test scored out of 100 points. The average score across subjects is approximately 70, with a standard deviation of 10. We observe test scores for the same student in both Grade 7 and Grade 8 Fall semesters. To facilitate interpretation and account for school- and grade-level variation, we standardize each subject score within school-grade cells to have a mean of zero and a standard deviation of one. We also construct an overall index of academic performance by aggregating the three test scores using a method commonly used in the literature (Anderson 2008, Chen and Yang 2019, Gong et al. 2021).³ We take the sum of the three individual standardized test scores for each student, weighting each item by the inverse of the covariance matrix of the standardized outcomes (Anderson 2008). The resulting overall index provides a composite measure of academic performance, with a higher value indicating better performance. This aggregation approach also helps address issues of multiple hypothesis testing; however, for the sake of completeness, we also present results using individual scores.

We measure non-cognitive ability using two indices: mental health and social adjustment. To construct the mental health index, we draw on student responses to survey questions about their emotional state over the past week. Specifically, students report the frequency with which they experienced feelings such as sadness, depression, unhappiness, lack of enjoyment, nervousness, or excessive energy that impairs concentration. Each item is rated on a 5-point Likert scale, where 1 denotes “never” and 5 denotes “always.” For consistency in interpretation, we reverse-code the responses so that higher values reflect better mental health. We then compute the average score across all items and standardize this index to have a mean of zero and a standard deviation of one within each school-grade cell.

The second dimension of non-cognitive abilities is social adjustment, which we create using the responses from four questions regarding participation in shared out-of-school activities with classmates and their overall school satisfaction. This conceptualization is grounded in established frameworks in developmental psychology and education research. A substantial body of literature indicates that engagement in out-of-school activities with peers fosters friendship formation, peer acceptance, and overall social integration, which are core components of social adjustment (Mahoney & Cairns, 1997; Mahoney et al., 2003; Fredricks & Simpkins, 2013). Our index follows a similar construction to the Social Acclimation and General Satisfaction Index in Gong et al. (2021). The first two questions ask about the frequency with which students visit museums, zoos, or scientific parks with classmates, and the frequency of watching movies, plays, or sports events. The answers for both questions use a five-point scale where 1 indicates “never” and 5 indicates “multiple times in a month.” The other two questions measure the extent to which the student agrees with statements about their confidence regarding their future and whether school life is boring.⁴ The questions employ a four-point scale, with 1 signifying “strongly disagree” and 4 denoting “strongly agree.” To establish a comprehensive index for students’ social adjustment, we employ a methodology akin to that used in the formulation of the academic success index (Anderson 2008). We standardize the scores for each question to achieve a mean of zero and a standard deviation of one for all children within each school-grade level. Subsequently, we consolidate the four z-scores, assigning weights to each item based on the inverse of the covariance matrix of the standardized results. Higher values of the overall z-score index signify enhanced levels of social adjustment.

In addition to the main results, our study uses many control variables to account for factors that may affect student outcomes. These include student characteristics like kindergarten attendance, gender, ethnicity, minority and migration status, whether they are an only child, grade repetition or skipping a grade, and age. We also consider family background such as whether the student’s parents have a high school degree, and their health and habitual behaviors such as smoking or drinking. For teachers, we consider their experience, age, gender, awards, education, certification, and professional title.⁵ Finally, at the classroom level, we control for classroom size, the fraction of female peers, and the fraction of peers who have migrated from other cities.

B. Summary statistics

Our study is restricted to kids with complete data on kindergarten attendance and outcomes. This exclusion is not limiting as fewer than one percent of the observations are eliminated based on these criteria. Further, to ensure that student characteristics are not systematically selected when we keep only those with non-missing data, we conduct tests of correlations between characteristics and the likelihood of missing data, following the approach of Xu et al. (2022). Our results, presented in Appendix Table 1, demonstrate that student characteristics are not significantly associated with the likelihood of missing values.

We present the summary statistics of the study sample by KG attendance status in Table 1. In the full sample, 85 percent of the students reported having attended kindergarten before entering primary school. Panel A shows that students who attended KG have improved academic scores and better non-cognitive abilities (both mental health and social adjustment) as compared to those who did not attend KG. Panels B and C present student demographic and other characteristics. Overall, students who attended KG have a somewhat more favorable family and socioeconomic background than those who did not attend, a finding consistent with Shin (2024). In particular, the parents of those who attended KG are more likely to have completed high school and college, and the students themselves are more likely to be an only child, and less likely to have repeated a grade. In terms of teacher characteristics, students who attended KG have teachers with more teaching experience. As for classroom characteristics, students with KG attendance tend to be in slightly larger classrooms with more students.

4. Empirical Strategy

Following Gong et al. (2021) and Xu et al. (2022), we estimate the peer effect of KG attendance using the following specification:

$$Y_{ics} = \alpha + \beta_1 \text{PeerKG}_{-ics} + X_{ics}'\phi + W_{ics}'\tau + \lambda_s + \varepsilon_{ics} \quad (1)$$

where i denotes a student, c is classroom, and s is school. Y_{ics} is an outcome variable such as academic performance or non-cognitive abilities. PeerKG_{-ics} is the fraction of students in the classroom that have attended kindergarten, excluding student i . Student i 's demographic and family background as described in Section II and noted in Panel B of Table 1 are in X_{ics}' .⁶ Classroom level covariates described in Section II and listed in Panel C of Table 1 are represented in W_{ics}' . School fixed effects are in λ_s and ε_{ics} is the error term. Standard errors are clustered at the classroom level. We run the same specification using wave one and wave two data separately to estimate the short and medium-run effects, respectively.

Given that random assignment to classrooms is a crucial component of our identification strategy, it is essential to explore it more thoroughly. Starting in the early 2010s, Chinese middle-schools commenced assigning pupils to classrooms in a random fashion. This differs from a system in which student allocation is determined by results from placement examinations administered prior to school admission. The random assignment was conducted by many

methods, the most widespread being the utilization of a computer program. In instances where the seats were limited, parents drew chits to determine their child's placement, as in a lottery system.

We formally address two sources of bias arising from selection. First, we examine the selection of students into classrooms. To correct for this, we limit our analysis to schools where both the headmaster and the homeroom teacher confirm that classroom assignment was random in Grade 7, as previously mentioned. For the medium run analysis, we further narrow our sample to schools that did not reassign classes in Grade 8 based on student test scores. Both of these restrictions provide some reassurance that, after a student selects a school, their classroom peers are assigned randomly. That is, the inclusion of only such schools ensures that our analysis is not biased by the sorting of students into classrooms based on observable and/or unobservable characteristics. The second issue we address is that students may endogenously choose schools. We correct for this possibility by using school fixed effects. Consequently, our estimates are derived from variations in peer kindergarten status across classrooms within the same school. School fixed effects also account for neighborhood or other similar time-invariant factors that may lead to selection at the school level.

To the extent that students in the estimation sample are randomly assigned to classrooms, and that this assignment remains unchanged over the study period, our sample is relatively less affected by concerns regarding self-selection of students to classrooms and/or peers. To provide additional reassurance on the integrity of self-reported data from school principals and teachers on the random assignments, we conduct several additional validity checks. We begin by assessing the correlation between pupils' background characteristics and the fraction attending preschools, while controlling for school fixed effects. Under random allocation within a school, there should be no systematic correlation between student attributes and the proportion of peers who attended kindergarten when controlling for school fixed effects. Estimates in column 2 of Table 2 indicate that all student background variables are statistically insignificant, and an F-test for the joint significance of all student demographic and family characteristics is insignificant (p -value of 0.79). These results underline that predetermined factors are not systematically associated with the proportion of kindergarten attendance in a classroom.

Although class assignments may not be influenced by student demographics and familial attributes, schools may systematically allocate teachers to classrooms. For example, Xu et al. (2022) notes that if classrooms contain fewer pupils with kindergarten experience (and hence potentially lower average ability), a school may provide more experienced teachers in these cases. We evaluate this by regressing the proportion of kindergarten participants in a class against teacher attributes in that class. The findings in column 3 of Table 2 demonstrate that, after accounting for school fixed effects, teacher characteristics are not systematically correlated to the fraction of pupils possessing KG education in the classroom. Next, we incorporate both student and teacher characteristics in column 4 of Table 2. An F-test assessing the joint significance of

these variables yields a p -value of 0.87, indicating that we fail to reject the null hypothesis that these variables are jointly equal to zero. We conclude that in our sample, student and teacher variables are not systematically linked to the fraction of peers who attended kindergarten.

We note that the joint F-test is the appropriate criterion for evaluating random assignment rather than any individual coefficient's significance. With the number of covariates included in column 4 of Table 2, sampling variation alone would generate some individually significant coefficients even under true random assignment. The joint F-test at $p = 0.87$ is the decisive evidence that classroom assignment is not systematically related to peer KG share. We also note, as Guryan et al. (2009) point out, that balancing regressions in peer effects studies can be subject to a bias arising from the omission of the student's own treatment status. We address this by including a control for each student's own kindergarten attendance in all balancing regressions; our results are unchanged.

Lastly, even with random assignment of students to middle-school classrooms, it could be that the *peer KG* effects we estimate reflect broader aspects of peer quality rather than the impact of peer KG attendance alone. If peer characteristics are themselves shaped by KG exposure, they may act as mediating channels through which treatment effects operate—a hypothesis we investigate in our analysis of mechanisms. At the same time, such characteristics may also be driven by pre-KG inputs. For instance, KG enrollees may be more likely to come from higher-income households that provide enhanced early-life investments, thereby conflating KG exposure with pre-existing socio-economic advantages. While the ideal approach to rectifying this issue would be to include direct measures of pre-KG inputs, our data do not provide these details. Instead, we control for a comprehensive set of peer-level characteristics that serve as proxies for socio-economic background. These are supplemented with extensive controls at the individual, household, and classroom levels (see panels B and C in Table 1), designed to mitigate omitted variables and other sources of bias. Importantly, our robustness checks (in Section VI) indicate that the inclusion of additional peer-level covariates—such as parental education and hukou status, which are plausibly determined prior to KG enrollment—has a negligible impact on our results. This stability suggests that unobserved peer characteristics are unlikely to be driving our main findings in any substantive way. That said, we can only do what our data allows, and cannot entirely rule out the influence of unobserved attributes. Despite this acknowledgement, given the institutional features of our setting, the random assignment of students to classrooms, the richness of our covariate set, and the robustness checks we conduct, we believe any potential bias to be limited in both magnitude and economic consequence.

We end this section by noting that in order to assess the impact of peer kindergarten attendance on individual outcomes, it is necessary to observe adequate variation in the measure of peer kindergarten attendance. As depicted in Figure 1, our sample exhibits significant variation in peer kindergarten attendance, with the measure ranging from a minimum of 0.34 to a maximum of 1.0. This is also underscored by the fact that the $1 - R^2$ from the model that regresses peer kindergarten proportion on school fixed effects is equal to 0.38.

5. Results

A. Main results

Figure 2 consists of two panels that display our outcomes of interest on the y-axis and the proportion of peers who attended kindergarten in a student's classroom on the x-axis. We generate separate graphs for the two outcomes of interest. These plots illustrate a positive correlation between the percentage of classroom peers who attended kindergarten and students' academic performance (left panel), and non-cognitive skills (right panel) in the medium term (shown in red), in contrast to a negligible association noted in the short term (shown in blue). To model these relationships in a regression framework, we employ the specification in Equation (1). Table 3 presents the short-term impact of peer kindergarten attendance on academic and non-cognitive outcomes. The estimated effect is small and statistically insignificant, reflecting the graphical representation. We hypothesize that this is attributable to the relatively short time that has elapsed since these peers were in the same classroom, resulting in limited opportunities to interact with and to influence one another.

Turning to the medium-run effects, we examine the impact of peers' kindergarten attendance on student performance in Grade 8, when they have had 14-18 months in the same classroom with the same set of peers. Table 4 presents estimates for all outcomes under our preferred full-controls specification: column 1 reports academic performance, column 2 reports the composite non-cognitive index, column 3 reports social adjustment, and column 4 reports mental health.

There are several key findings in Table 4. First, attending kindergarten during childhood positively correlates with a significant improvement in Grade 8 academic performance. Specifically, we find in column 1 that attending kindergarten in childhood is associated with an increase in own academic performance by around 20 percent of a standard deviation in Grade 8. These findings are in line with the extensive literature on the beneficial effects of kindergarten attendance on school performance (Behrman et al. 2024; Dean and Jayachandran 2020, Garcia et al. 2020, Hazarika and Viren, 2013). Specifically, this effect size is comparable to those found in the 40th to 50th percentile of the distribution of effects reported in 96 studies from low and middle-income countries on various interventions aimed at improving educational outcomes (Evans and Yuan 2022). Other studies that report similar magnitude of effects include the evaluation of a large pre-primary education expansion in Argentina, which found that one year of pre-primary school increased average third-grade test scores by 23 percent of a standard deviation (Berlinski et al. 2009). Additionally, a meta-analysis of twenty-two studies on early childhood education in the US showed that participation in such programs increased high school graduation rates by approximately 0.26 standard deviations (McCoy et al. 2017). In particular, we build on Zhang et al (2023) by carefully distinguishing between short-term and medium-term impacts of peers. This distinction is critical, as it highlights the cumulative nature of peer spillovers, suggesting that the benefits of early childhood education may only materialize through sustained social interactions and adaptive classroom dynamics over time.

Second, the coefficient for peer KG in column 1 of Table 4 is statistically significant and positively associated with academic performance, indicating that students in classrooms with a higher proportion of kindergarten-attending peers achieve higher academic scores on average. Specifically, a one-percentage-point increase in the proportion of peers who attended kindergarten leads to an increase of 0.72 percent of a standard deviation in academic scores. To illustrate the significance of the effect, consider a class with the average size of 49 students in our dataset. Incorporating each additional student who attended kindergarten raises the proportion of peer kindergarten attendance by approximately 2 percent ($1/49$). This means having an additional student with kindergarten experience increases peers' academic achievement by 1.44 (0.72×2) percent of a standard deviation in Grade 8. Given that the own effect of attending kindergarten is 20 percent of a standard deviation (based on our estimation and previous studies), the externality of the positive spillover effect amounts to roughly 7.20 percent of the direct effect of kindergarten on test scores. This is noteworthy as it is essentially a positive externality of attending KG that accrues over and above the direct effects documented in the literature.

The magnitude of effects that we find is comparable to other studies that consider classroom peer effects on test scores. For example, Xu et al (2022) finds that a one-percentage-point increase in the proportion of peers who repeated a grade decreases academic performance by almost 2.10 percent of a standard deviations among students who have never repeated a grade. In another study, Gong et al (2021) notes that a one-percentage-point increase in the proportion of female classmates raises a student's test score by 1.02 percent of a standard deviation.

We next focus on non-cognitive outcomes, reported in columns 2–4 of Table 4. We report a positive and statistically significant effect of peer kindergarten on a composite index of non-cognitive skills, where a one-percentage-point (approximately 0.10 SD) increase in the proportion of peers who attended kindergarten leads to a 0.74 percent of a standard deviation increase in non-cognitive abilities. This effect size implies that a one-SD increase in peer fraction with kindergarten experience improves non-cognitive abilities by 7.40 percent of a SD. This is consistent with prior research examining the influence of classroom peers on non-cognitive skills. For instance, Hill and Zhou (2021) demonstrates that a one-standard deviation rise in the proportion of classmates experiencing parental conflict elevates the unhappiness of each student by 8 percent of a standard deviation. Zhou and Wang (2023) notes that a one-standard deviation increase in classmates encountering an early childhood health shock diminishes a student's school engagement score by 10 percent of a standard deviation.

Similar to the case of peer effects on test scores, we contextualize the magnitude of the effect on non-cognitive abilities. Again, consider a class with the mean class size (49 students in our sample). Adding one more student who attended kindergarten increases the fraction of peer kindergarten attendance by about 2 percent. This means having an additional student with kindergarten experience increases peers' non-cognitive achievement by 1.48 (0.74×2) percent of a standard deviation in Grade 8. Given that the own effect of attending kindergarten is 10 percent

of a standard deviation (second row, column 2, Table 4), the magnitude of the positive spillover effect amounts to roughly 14.8 percent of the direct effect of kindergarten on non-cognitive abilities.

The index outcomes presented in Tables 4 and 5 are derived by aggregating multiple underlying factors as per Anderson (2008), thus reducing the pitfalls associated with multiple hypothesis testing. Considering these separately, Appendix Figure 1 shows that peer kindergarten has a positive influence on most individual factors. These effects are stronger for social skills, which are important for non-cognitive abilities. Also, more peers with kindergarten experience leads to students being more likely to engage in extracurricular activities like visiting museums, zoos, or science parks, and attending cultural events like movies, plays, or sports. The effects are also significant for subjects such as Chinese and math. Overall, the benefits of peer kindergarten attendance are larger for non-cognitive skills than for academic performance, consistent with existing literature on classroom peer effects (Zhou and Wang 2023).

The aggregate indices constitute our primary outcomes for inference; results on individual components presented in the Appendix should accordingly be interpreted with appropriate caution. This approach is equivalent in spirit to applying a Simes (1986) correction across the family of component outcomes, and the aggregate p -values reported in Tables 4 and 5 already account for the joint nature of the tests.

B. Heterogeneous impacts

We will now focus on our medium-term outcomes, starting with an analysis of heterogeneities across several dimensions, including the student's gender and their household's socioeconomic position (mother's education, rural-urban hukou classification, and migrant status).

Studies indicate that boys are more vulnerable to social pressures and generally do poorly in adverse circumstances. More specifically, boys from fractured households exhibit comparatively inferior academic performance than girls (Bertrand and Pan 2013). Additionally, two early-life intervention programs in the United States targeting underprivileged children, specifically the Perry Preschool Project (PPP) and the Carolina Abecedarian Project (ABC), demonstrated significant gender-specific benefits on adult outcomes (Conti et al. 2016). Focusing on gender in our analyses, we find that the proportion of classmates who attended kindergarten positively influences most outcomes for both male and female students, with the exception of male academic performance, as indicated in Panel A of Table 5. The difference in coefficients between the two genders in columns 1 and 2 is not statistically significant however, indicating comparable impacts of peer kindergarten by gender.

To explore gender heterogeneities more comprehensively, we split the main *peer KG* variable into two components: the proportion of female peers who attended kindergarten and the proportion of male peers who attended kindergarten. This is motivated by existing research indicating that friendship networks in middle-school often exhibit significant homophily with respect to gender and social background (An 2022). We present the results of this analysis in

Appendix Table 2, where we regress academic performance and non-cognitive outcomes separately for female and male sub-samples of students on *peer KG* attendance differentiated by gender. Our results indicate that the peer kindergarten effect on academic performance for females in column 1 is largely driven by their female peers (a significant coefficient of 0.55); the coefficient for male peers in this column is statistically insignificant. Similarly, male peers have a large significant effect on male students in the case of non-cognitive outcomes in column 4. These results broadly confirm homophily, and indicate that peers of the same gender exert stronger influence on an individual's outcomes, consistent with past evidence (Laniado et al. 2016, An 2022).

We next explore whether effects vary by distribution of the outcome variable. In other words, whether the effect of peer kindergarten on academic performance and non-cognitive outcomes is different for individuals with varying levels of ability. The effect on academic performance falls at higher quantiles, implying that students with better academic performance benefit less (left panel, Figure 3). This result is intuitive as individuals with higher academic performance may have less to gain from higher-quality peers. It's worth noting, however, that these effects are not statistically significant at the left tail of the distribution. We observe a similar pattern for peer effects on non-cognitive abilities in the right-hand panel of Figure 3, although in this case, it is the estimates in the middle of the distribution that are statistically significant. Overall, these findings suggest that the beneficial effects of peer kindergarten on academic performance and non-cognitive outcomes decline with individual ability.

We investigate whether maternal characteristics influence how peer KG attendance affects student outcomes. A study in Japan substantiates the advantageous impacts of early education on children in challenging home environments, indicating that early childcare enhances language development and mitigates inattention, hyperactivity, and aggression, particularly for those with mothers who have little education (Yamaguchi et al. 2018). We divide our sample based on mother's education (following Gong et al. 2021, we consider whether a student's mother completed college). Results in Panel B of Table 5 indicate significant differences in effects of peer KG on academic performance, with children of mothers who did not complete college benefiting more. This is also true when we consider non-cognitive outcomes. While the difference in effects across the two groups is not statistically significant for academic performance, it is measurably distinct at the one percent level for non-cognitive outcomes. The finding of greater effect among children with low educated mothers is likely because peer KG substitutes for parenting quality and knowledge (Yamaguchi et al. 2018).

We also examine whether peer effects differ based on rural-urban hukou status (school location). Panel C of Table 5 reveals that while both rural and urban students benefit from peer KG attendance in terms of non-cognitive outcomes, the effects are significant for academic performance only in the case of rural students. This is in line with our earlier observations that disadvantaged students (those with low ability or those with mothers who have not completed college) benefit more from peer KG effects. However, we refrain from drawing strong conclusions due to the absence, again, of stark statistical differences.

Relatedly, we explore whether students from migrant households (internal migrants within China) experience differential effects. This is important given the significant scale of domestic migration in China, which has increased dramatically from less than 7 million in 1982 to around 221 million in 2010 (Duan et al. 2013). Our results, reported in Panel D of Table 5, indicate that non-migrants in particular benefit from peer KG effects in terms of academic performance, and the difference across groups is statistically significant at the one percent level. This may be because peer effects are stronger in terms of academics when students know each other well, which is more likely in classrooms with a larger share of non-migrant students. While both migrants and non-migrants benefit when non-cognitive outcomes are considered, the difference in effects across these groups is not significant.

Finally, we examine whether the peer KG effect differs by students' own kindergarten attendance status. Because students who did not attend kindergarten constitute only approximately 15 percent of our sample (roughly 500 students), this subgroup analysis is underpowered, and we report it here as suggestive rather than definitive. We find that the positive effects of peer KG on academic and non-cognitive outcomes are concentrated among students who themselves attended kindergarten, while the corresponding estimates for non-KG students are positive but imprecisely estimated. This pattern is consistent with the technology of skill formation (Cunha and Heckman 2007): students who have acquired foundational socio-emotional competencies through their own kindergarten experience may be better positioned to absorb and build on the behavioral norms conveyed by their KG-attending peers, reflecting the dynamic complementarity that characterizes non-cognitive skill development.

6. Mechanisms

We explore several mechanisms that might drive medium-run effects of *peer KG* on academic and non-academic outcomes. We classify these into different categories following the aggregation approach in Anderson (2008), and discuss each of them separately. Details regarding the various measures we use in each category are provided in Appendix Table 3. Although we create several composite indices, we also present results for each individual component in Appendix Table 4 below.

A. Student behavior and effort

We begin by considering various indicators of student behavior and effort reported in Panel A of Table 6. We create four different variables here – negative behavior index, smoking/drinking alcohol, going to arcades, and a homework related index. We regress each of these variables on peer KG attendance, controlling for the full set of covariates. We find that peer KG experience reduces negative behavior (such as use of bad language, fighting with others, and having a violent temper) and lowers rates of smoking and alcohol consumption, thus possibly contributing to improved academic outcomes. This is consistent with other evidence that documents a negative association between academic performance and smoking (Alqahtani et al. 2023) and alcohol consumption (Hjarnaa et al. 2023) among school students. Additionally, we find that

students in classrooms with higher peer KG attendance are likely to invest more time and effort in completing homework, especially doing well on perseverance and effort measures such as finishing homework even though it is distasteful or is taking a long time (columns 11 and 12 in Panel A of Appendix Table 4). In summary, having classroom peers with KG experience positively impacts many of the student behavior and effort indicators that determine success in school. Our results also indicate that peer KG characteristics in the classroom affect how students allocate their time outside of the classroom; they spend less time on visiting net bars or video arcades. This is likely to be another contributory factor to the positive effects on academic scores that we observe, and may also independently improve mental health (Tortolero et al. 2014).

B. Student socio-emotional abilities

Other factors that might be explanatory in our context are measures of a student's socio-emotional maturity, which can affect both their academic performance and emotional well-being. We investigate the effect of peer KG attendance on these outcomes in Panel B of Table 6 and Panel B of Appendix Table 4. In general, having a higher proportion of peers with kindergarten increases student measures of resilience (columns 1 and 4 in Panel B of Table 6), confidence, awareness, and emotional development (columns 2 and 3 in Panel B of Table 6). Confidence, measured by the ability to engage in conversation with adults effortlessly, and maturity, defined by the capacity to apologize for unintentional harm, exhibit the larger effects in the presence of a higher proportion of peers with kindergarten (Panel B of Appendix Table 4). This is broadly consistent with other studies evaluating effects of ECE (Heckman et al. 2013).

C. Teaching tools, teacher effort, and student-teacher interactions

We explore two dimensions across which teachers could plausibly mediate the observed effects: (i) teaching inputs and (ii) teacher effort/quality. We evaluate these outcomes to understand whether they vary depending on classroom composition. Educators may modify their pedagogical approaches, communication techniques, or feedback mechanisms according to the kindergarten experience of students, which can positively influence student outcomes by fine-tuning teaching standards to align with student capabilities, or negatively if they disproportionately prioritize high-ability students at the expense of those with lower abilities.

To evaluate effects of teacher inputs, we consider usage of multimedia in the classroom and total working hours as reported by teachers in columns 1 and 2 in Panel C of Table 6. Previous studies have shown that the use of multimedia by teachers can enhance learning outcomes. However, we find few effects. The insignificance of multimedia usage in column 1 may be largely attributable to a school's infrastructure level, which is likely to be unaffected by peer kindergarten status. Considering working hours next, our analysis reveals that the presence of peers with kindergarten experience has no impact on teacher effort in column 2. This result on teacher effort is reassuring as it suggests that the impact on academic scores can be more accurately ascribed to the presence of classmates with kindergarten experience, rather than to the fact that teachers alter their pedagogical approach or vary their effort in response to the composition of their students.

We further examine effects on teaching effort/quality through two composite indices: one measuring the inclusion of “discussion and interaction” in their teaching, and the other related to “students' perception of the teacher’s style.” We find positive effects on the latter (column 4 in Panel C of Table 6). Probing individual components of the aggregate measure in column 4 further, we find that having peers with kindergarten exposure reduces a student’s perception that their teacher would ignore or isolate them (column 5 in Panel C of Appendix Table 4), or criticize them publicly (column 6 in Panel C of Appendix Table 4). It also increases a student’s view that their teacher would engage their parents in resolving the challenges they were facing (column 9 in Panel C of Appendix Table 4). Beyond this, and again reassuringly, peer KG has no discernible impact in our evaluation of changes in teacher effort and teacher-student interactions.

We interpret the positive effect on students' perception of teacher helpfulness not as evidence of differential teacher assignment, but rather as a mechanism. Classrooms with a higher share of KG-attending peers exhibit fewer disruptive behaviors (as documented in Panels A and D of Table 6), which may allow teachers to dedicate more instructional time and attention to individual students, leading to a more favorable student perception of teacher engagement. This interpretation is consistent with the null result on objective teacher effort (working hours and multimedia use), which rules out the alternative explanation that teachers exert greater effort in response to classroom composition.

D. Friends/peer characteristics

We investigate how peer KG composition might affect the nature of the classroom, which, in turn, may affect academic and non-cognitive outcomes. Studies have found that the classroom environment has an important bearing on student outcomes (Feld and Zolitz 2017; Jackson, 2013). In particular, having disruptive peers can have a negative effect on academic performance. Carrell and Hoekstra (2010) estimate that children exposed to domestic violence at home adversely affect the reading and math test results of their peers by misbehaving and by heightening the probability of classroom disruptions. Similarly, Lavy et al. (2012) shows that low-ability pupils diminish the accomplishment of their peers by influencing teachers' pedagogical practices and by increasing violence and interruptions in the classroom. Zhao and Zhao (2021) identifies that children of alcoholic fathers exert adverse effects on peers, mostly manifested through heightened classroom disobedience and reductions in time allocated to homework, which necessitates alterations in teaching practices. In light of these factors, we evaluate a detailed set of outcomes related to characteristics of friends and peers with results presented in Panel D of Table 6.

A measure of classroom environment is how conducive to learning the class is. We measure classroom atmosphere using an index that aggregates two variables: (1) students’ agreement with the statement, “My class has a good atmosphere,” and (2) the average fraction of classmates who never repeated a grade during primary school. Prior research finds that a higher share of grade repeaters in a class negatively affects the academic and non-cognitive outcomes of others (Xu et al. 2022), highlighting the relevance of this measure for the learning environment. We

hypothesize that peers' kindergarten experience may generate positive spillover effects by reducing the prevalence of grade repetition and by improving the learning environment. Consistent with this mechanism, our estimates indicate that peer KG has significant positive effects on a class's atmosphere (column 1 in Panel D of Table 6).

We next consider friends' engagement and dedication in school through outcomes noted in column 2 in Panel D of Table 6. As evident, peer KG has a positive effect on this measure. In considering the underlying individual components that range from friends studying hard to expecting to go to college, a higher proportion of peers with KG experience has beneficial effects on these measures of student engagement in school (Panel D of Appendix Table 4). The remaining columns in Panel D of Table 6 consider behaviors of one's friends in terms of skipping classes and violating other school rules (details on their construction are in Appendix Table 4). We find that these undesirable behaviors decline with peers who have KG experience. In terms of the individual components in particular, and as noted above, we find that effects of KG exposed peers are most evident in terms of reduced smoking or drinking, as well as a lower likelihood of attending net bars and arcades (Panel D in Appendix Table 4). In summary, our findings in Panel D of Table 6 and Panel D of Appendix Table 4 resonate with other evidence in the peer effects literature that underlines the importance of classroom environment and peer quality in guaranteeing student success.

E. Attributing effects to different mechanisms

Before presenting the results, we briefly clarify the theoretical ordering that motivates the decomposition. We conceptualize the causal sequence as follows: a higher share of KG-attending peers first shapes the classroom environment, improving behavioral norms and reducing disruptive conduct (Panel D of Table 6). This improved environment then operates through two reinforcing channels: it raises students' own socio-emotional development through sustained interaction with better-socialized peers (Panel B), and it shifts students' own effort and behavior toward more productive patterns (Panel A). The teacher perception result (Panel C) is best understood as a downstream consequence of this process — fewer disruptions allow teachers to be more responsive to individual students — rather than as an independent mediating input. It is worth noting that while these channels are conceptually ordered, they are likely to operate simultaneously and to reinforce one another in practice. The decomposition below should therefore be read as a decomposition of statistical predictive power, not a strict causal sequence.

Methodologically, following the methods in Heckman et al. (2013) and Gelbach (2016), we compare the OLS coefficient on peer KG in the parsimonious specification (Equation 1) with the coefficient after including each set of mediators in turn. The difference in coefficients attributable to each mediator set, normalized by the sum of all such differences, yields the share of the explainable effect attributed to that channel. Figure 4 plots the proportions of all the explanatory mechanisms that underlie KG peer effects that we consider. To summarize, these mechanisms include student behavior, student socio-emotional skills, teacher-related mechanisms, friends' behaviors, as well as other factors. We find that for the effect on academic

test scores, student behavior explains approximately 13.40 percent, while friends' behaviors/attitudes explain around 5 percent. Including the other factors, the mechanisms can explain a combined 23.30 percent of KG peer effects on academic test scores.

We next consider the contribution of the various mechanisms on the effect of *peer KG* on non-cognitive outcomes. The pattern here is a little different; we find that a much higher proportion of the total effect is explained (85.50 percent), and that socio-emotional development contributes in a major way (23.20 percent). This is consistent with our findings as there is likely to be a high degree of correlation between socio-emotional skills that we explore and the non-cognitive outcomes that we evaluate. Additionally, friends' attitudes and behaviors also contribute significantly (38.20 percent), while students' own improved behavior (10.30 percent) and teacher attributes (14.80 percent) are other key components.

Since a fairly large proportion of the effect on non-cognitive outcomes is explained by the mechanisms we consider, we probe further. We conduct a decomposition analysis for the two components of our non-cognitive outcome index: Social adjustment and mental health. We find that the mechanisms we examine explain around 96.70 percent and 84.30 percent of the *peer KG* effect on social adjustment and mental health, respectively. For social adjustment, over half of the effect of *peer KG* is mediated through friends' attitudes/behaviors (52.80), followed by socio-emotional skills (26.10 percent) and teacher attributes (11.50 percent). For mental health, the highest proportion of the effect is explained by student's own behavior (26.50 percent), followed by teacher attributes (26.30 percent) and socio-emotional skills of the students (22.30 percent).

7. Robustness Checks

A. Sorting on teacher characteristics

A potential issue touched on before is that the effects could be driven by differential teacher characteristics and teaching practices, which may lead to spurious correlations between test scores and *peer KG*. To address this, we take several steps. First, in Appendix Table 5, we regress various teacher characteristics (experience, awards received, age, gender, education, experience, and certification) on *peer KG* and find that there are few significant effects. Hence *peer KG* does not affect key teacher characteristics. As an additional check we include these teacher controls in all models and find that our results remain unaltered.

Second, the fact that we find significant impacts across both Chinese and Math in Appendix Figure 1 is reassuring. This is because while Math is likely to have more objective components which lowers the likelihood that teacher characteristics can influence grades, the fact that we find results for Chinese as well suggests that on average, teachers are not using discretion in their grading.

Third, we note that there are limited differences in content creation, grading procedures, and other practices across teachers of the same grade within a school, thus limiting the extent to which teacher characteristics and effort may influence our findings. Uniformity in content and

procedures throughout grades arises from compulsory schooling regulations, wherein the middle-school curriculum is established by a central authority, the National Ministry of Education. All educational institutions are required to adhere to the same curriculum for each grade, and educators lack autonomy about the content of the courses they instruct. Generally, educators within each institution establish teaching groups according to grade levels and disciplines, and on regular instructional days, they collaboratively discuss and develop educational materials and tasks.

Furthermore, several cities use standardized examinations and evaluations at the grade-subject tier. These procedures afford minimal latitude for teacher discretion on syllabi, instructional hours, course difficulty, volume of material addressed in a particular academic year, and examination grading. During examinations (mid-year and finals), educators instructing a specific grade level within a school allocate grading responsibilities such that each question is generally assessed by the same instructor utilizing a uniform rubric, collaboratively established by all teachers. Grading practices are also double-blind; identifying information of students (name, class, and ID) is hidden from the grader, while a student does not know which of the teachers in their grade was responsible for grading their exam. Considering all these factors, we conclude that our results are unlikely to originate primarily from differences in teaching practices and grading styles.

B. Functional form of test score and non-cognitive outcomes

In the previous analyses, our two main variables, namely academic performance and non-cognitive abilities, are aggregated from several underlying components following the approach in Anderson (2008). As a robustness check, we now use another widely adopted approach to generate the index outcomes (Kling et al. 2007). In this method, we first normalize the scores of each component to have a mean of zero and a standard deviation of one. We then take the simple average of the z-scores for each category to generate the index outcome. The main difference from the Anderson (2008) approach lies in the second step, in that we do not weight based on the covariance matrix of the standardized outcomes. We then re-estimate the main regression and report the results in the Appendix Table 6. As shown in columns 1 and 2, the results are statistically significant at the 5 percent level and generally in the same ballpark in terms of magnitude as those in the main results of Tables 4 and 5, especially for academic performance. We conclude that our results are not driven by the particular way our index outcomes are constructed.

C. Addressing enrollment into kindergarten

As mentioned in section III, *peer KG* effects we estimate may reflect broader aspects of peer quality. In particular, KG enrollees may be more likely to come from higher-income households that provide enhanced early-life investments, thereby conflating KG exposure with pre-existing socio-economic advantages. To address unobserved peer characteristics—particularly those shaped prior to peers' kindergarten (KG) enrollment and potentially correlated with current peer

attributes—we augment our main specification with a detailed set of peer-level controls. Specifically, we include indicators for the proportion of peers from low-income households, those holding a rural hukou, and whether mothers and fathers have attained at least a high school education. These variables are plausibly determined before peer KG enrollment, and are likely to be correlated with a range of early-life inputs and the overall environment that could otherwise be confounding. As reported in Appendix Tables 7 and 8, the estimated effects of *peer KG* exposure on both academic and non-cognitive outcomes remain stable and precisely measured. Thus, unobserved peer characteristics are unlikely to be influential in any meaningful way.

D. Dropping two schools at a time

To test whether our results are driven by a selected set of schools, we randomly exclude two schools at a time from our sample of 48 schools and re-estimate our main specification. The intuition is to check if our results are impacted by dropping some proportion of our sample schools ($2/48$, which is about 4 percent). We estimate 1128 regressions (C_2^{48} regressions) for each outcome, and plot the distributions of the estimated coefficients in Appendix Figure 2. The figure shows that for both academic and non-cognitive indices (the same measures as in the main results of Tables 4 and 5), the coefficient of interest almost always retains its positive sign and rarely loses significance. For the non-cognitive score, none of the regressions (out of 1128 regressions) yield an impact that has a negative sign, while for academic performance, the fraction that does is trivial at 0.44 percent (5 out of 1128 regressions). These patterns underscore that our results are robust to the exclusion of specific schools.

8. Discussion and Policy Implications

While there is ample evidence of the positive effects of kindergarten attendance on own educational outcomes, few studies have considered the influence of peer effects from kindergarten attendance. This study addresses this gap in the literature by examining the impact of peer kindergarten attendance on students' cognitive and non-cognitive development in adolescence (middle-school). Using nationally representative data from the China Education Panel Survey, we leverage random assignment of students into classrooms to demonstrate that peer kindergarten attendance has a significant and economically meaningful effect on both cognitive and non-cognitive outcomes. Specifically, a ten-percentage point increase in the fraction of peers who attended kindergarten raises test scores in math, English, and Chinese by 7.24 percent of a standard deviation. We also find comparable effects on non-cognitive outcomes, including mental stress indicators and social adjustment measures. Overall, our results suggest that peer kindergarten attendance has significant impacts on students' academic and personal development, net of own kindergarten status. Our findings underline that peer composition, an underexplored mechanism, shapes cognitive and non-cognitive outcomes in adolescence. This highlights an avenue that helps to mitigate fade-out in individual gains from ECE that has been documented (List and Uchida 2024).

We examine heterogeneity in the observed effects and find statistically distinct beneficial effects primarily for students whose mothers have not completed college, and for those who are non-migrants. The results for those with less educated mothers suggest that peer kindergarten attendance may help reduce socio-demographic inequities and improve opportunities. We then explore mechanisms underlying these effects. We find evidence in support of improved student effort towards learning: more time spent working on homework and less time spent on leisure activities like going to net bars or video arcades. Additionally, students report feeling more engaged at school and experiencing a classroom environment with an atmosphere conducive to learning. A larger fraction of classroom peers who attended kindergarten also leads to more favorable views about classroom teachers. We find limited evidence that teachers change their teaching style or effort in response to classroom composition. Our results are robust to a variety of methodological and specification checks. While previous studies have documented the positive effects of kindergarten attendance on own development, our research shows that accounting for the positive externalities of peers with kindergarten experience is important to understanding the overall benefits of early childhood education.

Our findings have two distinct, though related, policy implications, and it is important to keep them conceptually separate. The primary implication concerns classroom composition policy. Our estimated causal quantity is the effect of being assigned to a classroom with a higher share of KG-attending peers — not the effect of expanding ECE enrollment per se. This means that even holding ECE enrollment fixed, deliberate mixing of KG and non-KG attending students across classrooms could generate meaningful non-cognitive gains, particularly for disadvantaged students. Such policies are administratively tractable and do not require additional investment in ECE infrastructure, which is of direct relevance in resource-constrained settings. The secondary implication concerns the social returns to ECE expansion. To the extent that our estimates reflect the bundled characteristics of KG-attending peers, they speak to the additional benefits that accrue when ECE enrollment grows and a larger share of any classroom has acquired early childhood competencies. When considered alongside the direct returns to ECE attendees documented in the literature, our findings suggest that standard program evaluations may understate the true social value of early childhood investment by omitting these peer externalities. However, it is also important to evaluate the quality of any ECE expansion: if sub-par, programs may result in fewer spillover benefits and could yield worse outcomes than comparable interventions such as home-based care (Britto et al. 2011; Rosero and Oosterbeek 2011; Schady et al. 2015; Fort et al. 2020). Overall, our findings underline that educational policymakers should consider both the direct and peer-mediated externalities of early childhood education when designing, targeting, and evaluating such programs.

We also assess the external validity of our findings using the SANS framework proposed by List (2020), which evaluates generalizability along four dimensions: Selection, Attrition, Naturalness, and Scaling. In terms of selection, our dataset is drawn from the China Education Panel Survey, a nationally representative survey of junior secondary students. The sampling frame spans 28 counties, capturing variation in socioeconomic conditions, institutional capacities, and

urbanization. Importantly, many of the sampled regions are lower-income and rural, reflecting the diversity of local conditions within China and resembling contexts that face similar challenges in rolling out universal early childhood education. Thus, the study sample is not only representative of the Chinese junior secondary population, but also broadly comparable to school systems in other middle-income countries (MICs).

In our case, there is no attrition (everyone who was surveyed in Grade 7 was also surveyed in grade 8), as our outcomes are measured in-school, and classroom rosters provide full coverage of assigned students. Peer composition is determined by random assignment within schools, limiting concerns about endogenous sorting. Compliance with data collection protocols is high, and the structure of the CEPS ensures that attrition does not bias estimates. These features enhance the reliability and generalizability of the estimated peer effects.

The study takes place within naturally occurring classroom environments, without overly restrictive experimental manipulation or artificial incentives. The observed behaviors—academic engagement, classroom dynamics, and socioemotional adjustment—occur in familiar school settings over a typical academic year. The task and decision margins (e.g., effort on homework, interaction with peers) are ones that students routinely face. As such, the setting closely mirrors real-world educational contexts, both in China and in comparable systems globally.

In terms of scaling, the mechanisms uncovered—peer spillovers driven by heterogeneity in early childhood investments—are not context-specific. They are likely operative in a wide range of MICs such as Indonesia, Vietnam, Kenya, and Peru, where ECE enrollment has grown rapidly but unevenly, often outpacing investments in quality. For example, Indonesia’s ECE program expanded nearly 40% between 2015 and 2022, yet regional disparities in access and quality persist (World Bank, 2023). Our findings highlight that peer (ECE) composition can generate persistent impacts on cognitive and non-cognitive outcomes. These results can inform how ECE programs are designed, targeted, and evaluated across diverse policy environments. Our analysis uses a nationally representative sample from the world’s second most populous country, is situated within an administratively scalable education system, and identifies mechanisms likely to operate in other middle-income settings. Therefore, we offer findings that hold relevance for a broad set of international contexts.

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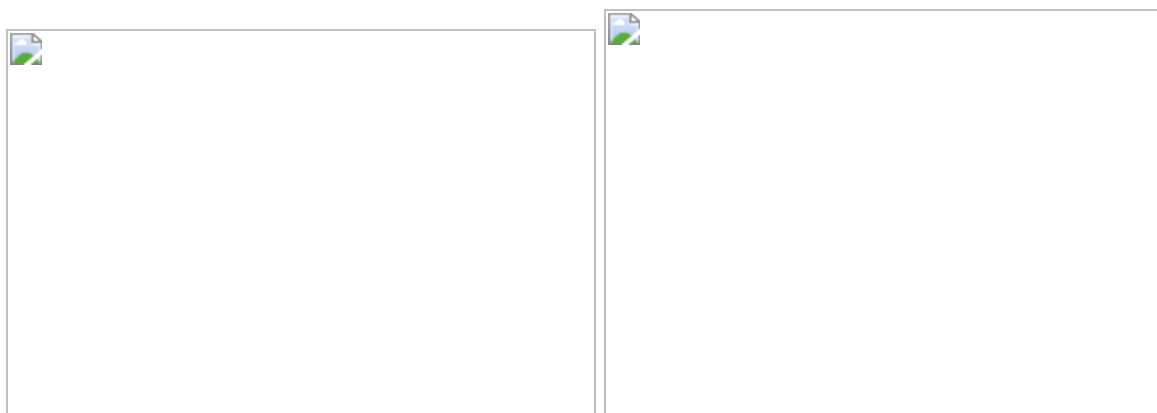
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Figures and Tables

Figure 1. Variation in the level of peer kindergarten levels in the sample



Notes: Authors' calculations. The second graph plots the density of the residuals of the fraction of peer kindergarten attendance. We obtain the residual by regressing peer kindergarten attendance on school fixed effects.

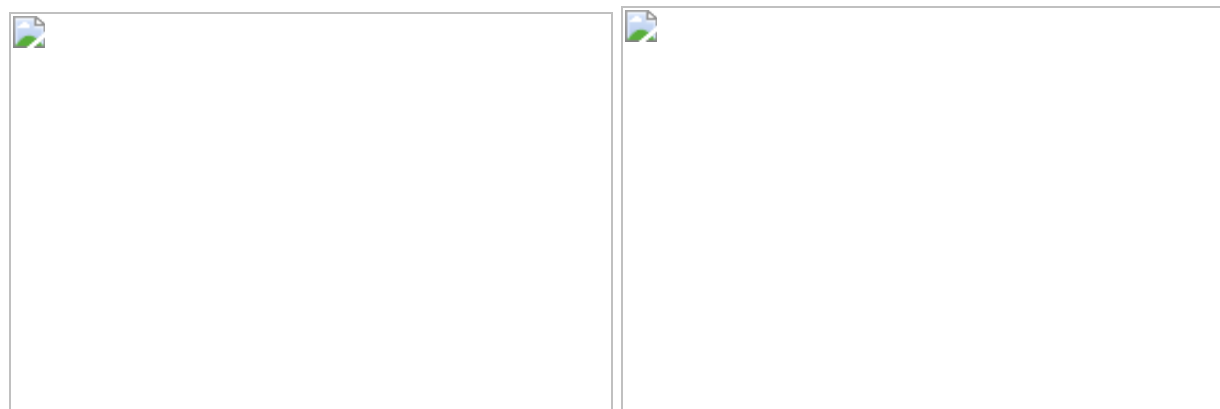
Figure 2. Relationship between peer kindergarten and academic and non-cognitive outcomes in the short and medium-run

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Notes: Authors' calculations. The lines represent the respective regressions estimated in each case.

Figure 3. Quantile effects



Notes: Authors' calculations. Each estimate comes from a separate regression, and the confidence intervals are at the 95 percent level of significance.

Figure 4. Proportions of the explanatory mechanisms that underlie KG peer effects



Note: This figure plots the estimated decomposition of kindergarten peer effects on five mechanisms, including student behavior, student socio-emotional skills, teacher-related mechanisms, friends' behaviors, as well as other factors (following methods in Heckman et al.

2013; Gelbach 2016). We separately conduct the decomposition analysis for each student outcome. The total is 100 percent – therefore, the leftover effect is unexplained (in each of them).

Table 1. Descriptive statistics of student demographics by kindergarten attendance

	(1)	(2)	(3)	(4)
	No-KG Students	KG students	Full sample	Diff: (2) – (1)
<i>A. Outcome variables</i>				
Academic performance	-0.276	0.144	0.0836	0.267***
	(1.043)	(0.879)	(0.916)	(0.038)
Non-cognitive outcomes	-0.185	0.136	0.0900	0.139**
	(1.076)	(0.956)	(0.980)	(0.045)
Social adjustment	-0.187	0.141	0.0939	0.142**
	(1.081)	(0.957)	(0.982)	(0.044)
Standardized mental health	-0.0812	0.0598	0.0394	0.102*
	(1.017)	(0.973)	(0.981)	(1.017)
<i>B. Student and family backgrounds</i>				
Peer KG	0.784	0.861	0.849	0.006*
	(0.147)	(0.102)	(0.113)	(0.003)
Female dummy	0.493	0.502	0.500	0.006
	(0.500)	(0.500)	(0.500)	(0.024)
Migrant status: non local	0.256	0.212	0.218	-0.035
	(0.437)	(0.409)	(0.413)	(0.018)
Minority	0.152	0.092	0.101	0.011
	(0.359)	(0.289)	(0.301)	(0.011)
Student age	13.190	12.890	12.940	-0.184***
	(1.074)	(0.835)	(0.881)	(0.028)
Are you the only child?	0.408	0.569	0.545	0.057**
	(0.492)	(0.495)	(0.498)	(0.021)
Repeat grade between 1 and 6	0.200	0.070	0.089	-0.076***
	(0.400)	(0.255)	(0.285)	(0.013)
Skip grade between 1 and 6	0.026	0.010	0.012	-0.012*
	(0.158)	(0.100)	(0.111)	(0.005)
Mother has at least completed high school	0.289	0.476	0.448	0.065**
	(0.454)	(0.500)	(0.497)	(0.020)
Father has at least completed high school	0.374	0.527	0.504	0.044*
	(0.484)	(0.499)	(0.500)	(0.020)

	(1)	(2)	(3)	(4)
Mother has completed college	0.104	0.209	0.193	0.035*
	(0.306)	(0.407)	(0.395)	(0.017)
Father has completed college	0.152	0.243	0.229	0.012
	(0.359)	(0.429)	(0.421)	(0.018)
Parent smokes	0.321	0.256	0.266	-0.000
	(0.467)	(0.437)	(0.442)	(0.021)
Parent drinks	0.449	0.433	0.435	0.003
	(0.498)	(0.496)	(0.496)	(0.024)
Parent in good or very good health	0.681	0.723	0.717	0.010
	(0.466)	(0.448)	(0.451)	(0.022)
<i>C. Teacher and classroom characteristics</i>				
Homeroom teacher's experience (years)	13.490	14.950	14.730	0.513*
	(8.921)	(7.889)	(8.068)	(0.232)
Homeroom teacher has province-level award	0.073	0.117	0.110	0.012
	(0.261)	(0.321)	(0.313)	(0.010)
Homeroom teacher has city-level award	0.330	0.407	0.396	0.010
	(0.471)	(0.491)	(0.489)	(0.017)
Homeroom teacher has county-level award	0.668	0.688	0.685	0.029
	(0.471)	(0.463)	(0.465)	(0.017)
Homeroom teacher has school-level award	0.773	0.748	0.752	-0.004
	(0.419)	(0.434)	(0.432)	(0.016)
Age of homeroom teacher	35.540	36.760	36.580	0.391*
	(7.347)	(6.634)	(6.759)	(0.183)
Homeroom Teacher female	0.625	0.705	0.693	0.016
	(0.485)	(0.456)	(0.461)	(0.016)
Homeroom teacher edu: Adult higher education	0.469	0.528	0.519	0.002
	(0.499)	(0.499)	(0.500)	(0.016)
Homeroom teacher edu: College or higher	0.037	0.038	0.038	-0.012
	(0.188)	(0.191)	(0.190)	(0.007)
Homeroom Teacher graduated from a normal univ.	0.945	0.952	0.951	-0.001
	(0.228)	(0.214)	(0.216)	(0.008)
Homeroom Teacher has a teacher certification	1.000	1.000	1.000	0.000

	(1)	(2)	(3)	(4)
	(0.000)	(0.000)	(0.000)	(0.000)
Homeroom teacher's professional title in teaching	1.515	1.808	1.764	0.042
	(0.815)	(0.787)	(0.798)	(0.024)
Teacher-Student same gender	0.509	0.510	0.510	0.010
	(0.500)	(0.500)	(0.500)	(0.024)
Number of students in class	48.280	49.600	49.400	0.480**
	(13.620)	(12.860)	(12.980)	(0.155)
Fraction of female peers in the classroom	0.482	0.485	0.485	0.001
	(0.077)	(0.068)	(0.069)	(0.002)
Fraction of migrant peers in the classroom	0.243	0.231	0.232	-0.000
	(0.256)	(0.200)	(0.209)	(0.003)
Observations	546	3088	3634	

Notes: Column 4 reports the difference in control variables between the kindergarten group (column 2) and the no-kindergarten group (column 1), controlling for school level fixed-effects. That is, we regressed the outcome variable on the kindergarten attendance indicator, controlling for school fixed-effects.

Table 2. Testing random assignment of students to classrooms

	(1)	(2)	(3)	(4)
Dep. Var.: <i>Peer KG</i>				
Female dummy	0.001	0.001		0.000
	(0.001)	(0.001)		(0.001)
Migrant status: non local	0.003	0.003		0.003
	(0.004)	(0.004)		(0.004)
Minority	0.018	0.018		0.010**
	(0.014)	(0.014)		(0.004)
Student age	-0.002	-0.002		0.000
	(0.003)	(0.003)		(0.001)
Are you the only child?	0.006	0.005		0.003
	(0.004)	(0.003)		(0.002)
Repeat grade between 1 and 6	-0.013	-0.013		-0.009*
	(0.009)	(0.009)		(0.004)
Skip grade between 1 and 6	-0.002	-0.002		-0.002
	(0.009)	(0.008)		(0.007)

	(1)	(2)	(3)	(4)
Mother has at least completed high school		0.002		0.002
		(0.002)		(0.002)
Father has at least completed high school		0.003		-0.001
		(0.005)		(0.002)
Parent smokes		-0.003		-0.000
		(0.005)		(0.002)
Parent drinks		0.001		0.002
		(0.002)		(0.002)
Parent in good or very good health		0.002		-0.001
		(0.004)		(0.002)
Homeroom teacher's teaching experience (years)			-0.002	-0.002
			(0.004)	(0.004)
Homeroom teacher has province-level award			0.005	0.006
			(0.050)	(0.049)
Homeroom teacher has city-level award			0.003	0.003
			(0.023)	(0.023)
Homeroom teacher has county-level award			0.029	0.029
			(0.024)	(0.024)
Homeroom teacher has school-level award			-0.003	-0.003
			(0.020)	(0.020)
Age of homeroom teacher			0.004	0.004
			(0.005)	(0.005)
Homeroom Teacher female			0.031	0.030
			(0.033)	(0.033)
Homeroom teacher edu: Adult higher education			-0.003	-0.002
			(0.030)	(0.030)
Homeroom teacher edu: College education or higher			-0.081	-0.080
			(0.068)	(0.068)
Homeroom Teacher graduated from a normal university			-0.033	-0.032
			(0.045)	(0.045)
Homeroom teacher's professional title in teaching			0.009	0.009
			(0.028)	(0.028)

	(1)	(2)	(3)	(4)
Teacher-Student same gender			0.002	0.002
			(0.001)	(0.001)
Number of students in class			0.007*	0.007*
			(0.004)	(0.004)
R-squared	0.726	0.726	0.788	0.789
p-value of F-stat	0.768	0.792	0.723	0.871
Observations	3,634	3,634	3,634	3,634

Notes: The dependent variable in all columns is the fraction of peers who attended kindergarten. Column 1 regresses the fraction of peers who attended kindergarten on students' background characteristics. Column 2 adds family background. Column 3 includes homeroom teacher characteristics as control variables. Column 4 combines student variables in column 2 and teacher characteristics in column 3. All regressions include school fixed effects. Robust standard errors clustered at the class level are shown in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 3. Peer effect of kindergarten attendance in the short-run

	(1)	(2)	(3)	(4)
Variables	Academic Performance	Non-cognitive outcomes	Social adjustment	Mental Health
<i>Peer KG</i>	0.333	0.301	0.230	0.266
	(0.369)	(0.239)	(0.220)	(0.246)
Attended Kindergarten	0.185***	0.086*	0.075*	0.115***
	(0.042)	(0.043)	(0.042)	(0.043)
Dep. Var. Mean	0.044	0.036	0.039	0.009
R-squared	0.115	0.227	0.237	0.082
Observations	4427	4171	4285	4400
School FE	Yes	Yes	Yes	Yes
Child Controls	Yes	Yes	Yes	Yes
HH Controls	Yes	Yes	Yes	Yes
Teacher Controls	Yes	Yes	Yes	Yes
Peer Controls	Yes	Yes	Yes	Yes

Notes: The outcome variables use data when students were in Grade 7. The dependent variable in column 1 is an overall index of academic performance that aggregates the test scores of three main subjects (Chinese, math and English) (following the method by Anderson 2008). The outcome in column 2, non-cognitive abilities, is aggregated from two dimensions: mental stress and social adjustment. The outcome in column 3, social adjustment, is an aggregate index of four questions-- (1) The frequency with which students go to museums, zoos or scientific parks with classmates, (2) the frequency with which students watch a movie, play, or go to sports events, (3)

the extent to which the student agrees that he/she is confident about his/her future, and (4) the extent to which the student agrees that school life is not boring. Higher value of the social adjustment index indicates more positive outcomes. The outcome in column 4, mental health, is an average of ten questions asking the frequency that the respondent experienced the following feelings in the past seven days: Feeling blue, feeling depressed, feeling unhappy, feeling as if they do not enjoy life, having no passion to do anything, feeling sad, feeling nervous, excessive worry, feeling something bad will happen, too energetic to concentrate in class. Higher values indicate a high risk of mental health problems. Robust standard errors clustered at the class level are shown in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 4. Peer effect of kindergarten attendance in the medium-run

	(1)	(2)	(3)	(4)
Variables	Academic Performance	Non-cognitive outcomes	Social adjustment	Mental Health
<i>Peer KG</i>	0.724** (0.331)	0.743*** (0.197)	0.685*** (0.186)	0.463* (0.262)
Attended Kindergarten	0.192*** (0.041)	0.101** (0.042)	0.107*** (0.039)	0.075 (0.047)
Dep. Var. Mean	0.056	0.086	0.085	0.034
R-squared	0.403	0.228	0.236	0.070
Observations	3634	3473	3542	3534
School FE	Yes	Yes	Yes	Yes
Child Controls	Yes	Yes	Yes	Yes
HH Controls	Yes	Yes	Yes	Yes
Teacher Controls	Yes	Yes	Yes	Yes
Peer Controls	Yes	Yes	Yes	Yes

Notes: The outcome variables use data when students were in Grade 8. The dependent variable in column 1 is an overall index of academic performance that aggregates the test scores of three main subjects (Chinese, math and English) (following the method by Anderson 2008). The outcome in column 2, non-cognitive abilities, is aggregated from two dimensions: mental stress and social adjustment. The outcome in column 3, social adjustment, is an aggregate index of four questions-- (1) The frequency with which students go to museums, zoos or scientific parks with classmates, (2) the frequency with which students watch a movie, play, or go to sports events, (3) the extent to which the student agrees that he/she is confident about his/her future, and (4) the extent to which the student agrees that school life is not boring. Higher value of the social adjustment index indicates more positive outcomes. The outcome in column 4, mental health, is an average of ten questions asking the frequency that the respondent experienced the following feelings in the past seven days: Feeling blue, feeling depressed, feeling unhappy, feeling as if they do not enjoy life, having no passion to do anything, feeling sad, feeling nervous, excessive

worry, feeling something bad will happen, too energetic to concentrate in class. Higher values indicate a high risk of mental health problems. We report the results for individual indices in Appendix Figure 1. Robust standard errors clustered at the class level are shown in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 5. Heterogeneous impacts of peer KG along different dimensions

	(1)	(2)	(3)	(4)
Dependent Variables	Academic performance	Academic performance	Non-cognitive outcomes	Non-cognitive outcomes
Panel A: By Gender				
	<i>Female</i>	<i>Male</i>	<i>Female</i>	<i>Male</i>
<i>Peer KG</i>	0.869*** (0.268)	0.512 (0.433)	0.701** (0.269)	0.862*** (0.290)
<i>p</i> -value (H0: equality across groups)	0.231		0.670	
Dep. var. mean	0.266	-0.155	0.157	0.013
R-squared	0.437	0.366	0.255	0.229
Observations	1818	1816	1748	1725
Panel B: By Mother's Education				
	<i>Mother without college</i>	<i>Mother with college</i>	<i>Mother without college</i>	<i>Mother with college</i>
<i>Peer KG</i>	0.683* (0.373)	0.512 (0.486)	0.729*** (0.193)	-0.653 (0.537)
<i>p</i> -value (H0: equality across groups)	0.724		0.003	
Dep. var. mean	-0.044	0.473	-0.010	0.471
R-squared	0.391	0.396	0.229	0.156
Observations	2931	703	2784	689
Panel C: By Rural-Urban Hukou Status				
	<i>Rural</i>	<i>Urban</i>	<i>Rural</i>	<i>Urban</i>
<i>Peer KG</i>	0.955* (0.493)	0.273 (0.433)	0.614* (0.346)	0.602** (0.248)
<i>p</i> -value (H0: equality across groups)	0.110		0.974	
Dep. var. mean	-0.120	0.187	-0.177	0.277
R-squared	0.401	0.414	0.231	0.187
Observations	1554	2080	1461	2012
Panel D: By Migrant Status				

	(1)	(2)	(3)	(4)
	<i>Migrants</i>	<i>Non-Migrants</i>	<i>Migrants</i>	<i>Non-Migrants</i>
<i>Peer KG</i>	-0.809	0.885***	1.183*	0.601***
	(0.748)	(0.296)	(0.680)	(0.218)
<i>p</i> -value (H0: equality across groups)	0.010		0.328	
Dep. var. mean	0.026	0.064	0.101	0.081
R-squared	0.465	0.417	0.280	0.234
Observations	794	2840	740	2733
Child controls	Yes	Yes	Yes	Yes
HH controls	Yes	Yes	Yes	Yes
Teacher controls	Yes	Yes	Yes	Yes

Notes: The dependent variable in columns 1-2 is an overall index of academic performance that aggregates the test scores of three main subjects (Chinese, math and English). The dependent variable in columns 3-4 is an overall index of non-cognitive abilities that aggregate from two dimensions: mental stress and social adjustment. All regressions include a full set of control variables as in the last column of Table 4. Robust standard errors clustered at the class level are shown in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 6. Mechanisms

Panel A: Student behavior and effort				
	(1)	(2)	(3)	(4)
	Violent Behavior Index	Smoking or drinking alcohol	Going to net bars or video arcade	Homework Index
<i>Peer KG</i>	-0.587***	-0.361***	-0.376***	0.513**
	(0.218)	(0.066)	(0.103)	(0.219)
	[0.014]	[0.000]	[0.001]	[0.031]
Obs.	3555	3604	3604	3588
Panel B: Student socio-emotional abilities				
	(1)	(2)	(3)	(4)
	Deal with negative feelings	Ease of communication index	Have role models	Deal with tough situations
<i>Peer KG</i>	0.171	0.568***	0.592**	0.441**
	(0.186)	(0.155)	(0.279)	(0.205)

Panel A: Student behavior and effort				
	[0.408]	[0.001]	[0.045]	[0.045]
Obs.	3594	3560	3590	3573
Panel C: Teaching tools and teacher-student interactions				
	(1)	(2)	(3)	(4)
	Multimedia in teaching	Total working hours	Discussion and Interactions Index	Students perceive having a helpful teacher
<i>Peer KG</i>	0.066	-1.913	1.129	0.718***
	(0.316)	(11.291)	(0.911)	(0.198)
	[0.865]	[0.865]	[0.265]	[0.001]
Obs.	3681	3681	3439	3563
Panel D: The characteristics of friends/peers				
	(1)	(2)	(3)	(4)
	Class atmosphere	Friends Academic Index	Friends skipping class	Friends' - violating school rules
<i>Peer KG</i>	1.723***	0.823***	-0.496**	-0.694***
	(0.354)	(0.276)	(0.198)	(0.222)
	[0.000]	[0.007]	[0.022]	[0.005]
Obs.	3595	3555	3565	3555

Notes: Each outcome variable in this table is aggregated from several components following the approach by Anderson et al. (2008). Appendix Table 3 provides the details of the aggregation and definitions of individual components. Robust standard errors clustered at the class level are shown in parentheses. We report the adjusted p -values in square brackets to address the concern on multiple hypotheses testing (Simes 1986).

Appendix Figures and Tables

Appendix Figure 1. Peer effect of kindergarten attendance on individual components of academic and non-cognitive indices



Notes: The dependent variables in rows 1-3 are individual components of academic scores. The dependent variable in row 4 is mental health index that aggregates from ten items (following the method by Anderson 2008). Specifically, mental health is an average of ten questions asking the frequency that the respondent experienced the following feelings in the past seven days: Feeling blue, feeling depressed, feeling unhappy, feeling as if they do not enjoy life, having no passion to do anything, feeling sad, feeling nervous, excessive worry, feeling something bad will happen, and too energetic to concentrate in class. Higher values indicate a high risk of mental health problems. The dependent variable in row 5 is the social acclimation index that aggregates from four items (following the method by Anderson 2008). These four items are respectively the dependent variables in rows 6-9 which include (1) The frequency with which students go to museums, zoos or scientific parks with classmates, (2) the frequency with which students watch a movie, shows, or go to sports events, (3) the extent to which the student agrees that he/she is confident about his/her future, and (4) the extent to which the student agrees that school life is not boring. All regressions include a full set of control variables as in Table 4. Confidence intervals are at the 95 percent level.

Appendix Figure 2. Distribution of estimated coefficients when two schools were randomly excluded

Panel A: Academic performance Panel B: Non-cognitive scores



Notes: This figure plots the distributions of the coefficients from 1128 regressions when two schools were randomly removed at a time. Vertical dashed lines indicate our baseline estimates for the respective outcome variable.

Appendix Table 1. Missing patterns of key outcome variables

	(1)	(2)	(3)	(4)
Variables	Academic performance	Non-cognitive outcomes	Social adjustment	Mental health
<i>Peer KG</i>	-0.030 (0.032)	-0.075 (0.047)	-0.060* (0.036)	-0.037 (0.044)
Attended kindergarten	0.012 (0.010)	-0.001 (0.012)	0.000 (0.013)	0.001 (0.011)
Observations	3832	3832	3832	3832
R-squared	0.102	0.113	0.130	0.104
School Fixed Effects	Yes	Yes	Yes	Yes

	(1)	(2)	(3)	(4)
Full Controls	Yes	Yes	Yes	Yes

Notes: The dependent variable in each column is an indicator of whether a student is missing information in this outcome. All regressions include a full set of control variables as in the last column of Table 3. Robust standard errors clustered at the class level are shown in parentheses.

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

Appendix Table 2. Heterogeneous impacts by gender

	(1)	(2)	(3)	(4)
	Academic performance	Academic performance	Non-cognitive outcomes	Non-cognitive outcomes
Variables	Female	Male	Female	Male
<i>Peer KG</i> (among females)	0.546**	-0.241	0.295	0.095
	(0.250)	(0.396)	(0.278)	(0.279)
<i>Peer KG</i> (among males)	0.233	0.794	0.427	0.840**
	(0.335)	(0.532)	(0.332)	(0.366)
Observations	1818	1816	1748	1725
R-squared	0.436	0.367	0.255	0.230
School FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Notes: All regressions include a full set of control variables as in Table 4. Robust standard errors clustered at the class level are shown in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Appendix Table 3. Grouping and definitions of mechanism variables

Groups	Variables in Table 6	Corresponding Components of each index variable (Variables in Appendix Table 4)	Questions in the questionnaire and Scales of each item
Panel A: Student behavior and effort	Violent Behavior Index	Cursing or saying swearwords	How often did you do [ITEM] in past year? [1 never, 2 seldom, 3 sometimes, 4 often, 5 always]
		Quarreling with others	
		Having a fight with others	
		Bullying the weak	
		Having a violent temper	
		Unable to concentrate on one thing	
		Skipping classes	
	Smoking or drinking alcohol	Smoking or drinking alcohol	
	Going to net bars/ video arcade	Going to net bars or video arcade	

Groups	Variables in Table 6	Corresponding Components of each index variable (Variables in Appendix Table 4)	Questions in the questionnaire and Scales of each item
Panel B: Student socio-emotional abilities	Homework Index	Not Copy homework from others or cheat in exams	Same as above (original coding reversed)
		Try to finish homework even dislike it	
		Try to finish homework even taking long time	
	Deal with negative feelings	Usually I can recover from negative feelings soon by myself	How much do you agree with the following statement (1 strongly disagree, 2 somewhat disagree, 3 somewhat agree, 4 strongly agree)
		Usually I can recover from negative feelings with the help of others	
	Ease of communication index	I'm not shy	Same as above (original coding reversed)
		Usually I would join others rather than sit alone	
		I often talk when I'm with schoolmates	
	Have role models	I can chat with adults easily	How much do you agree with the following statements (1 strongly disagree, 2 somewhat disagree, 3 somewhat agree, 4 strongly agree)
		There are some adults I respect and admire	
	Deal with tough situations	I would apologize if I hurt others unintentionally	
I would try to find other ways if I do something wrong			
I can stay calm even in bad situations			
Usually I have confidence in my ability to fulfill task			
Panel C: Tools and teacher-student interactions	Multimedia in teaching	Multimedia in teaching	The fraction of subject teachers (Chinese, Math and English) that often use multimedia in teaching.
	Total working hours	Total working hours	The number of total working hours last week, averaged across three subject teachers.
	Discussion and Interactions Index	Discussion and Interactions	We first average the two variables indicating group discussions and interactions between teachers and students for each subject (Chinese, Math and English), and then take the average of three subjects.
		Hours of comm. btw homeroom teacher & students	The number of hours that the homeroom teacher spent on communicating with students after class everyday

Groups	Variables in Table 6	Corresponding Components of each index variable (Variables in Appendix Table 4)	Questions in the questionnaire and Scales of each item
Panel D: The characteristics of friends/peers	Students perceive having a helpful teacher	If I have the feelings mentioned above (i.e. negative feelings), My teacher would not ignore and isolate me	How much do you agree with the following statements (1 strongly disagree, 2 somewhat disagree, 3 somewhat agree, 4 strongly agree) (original coding reversed)
		If I have the feelings mentioned above (i.e. negative feelings), My teacher would not criticize me in public	
		If I have the feelings mentioned above (i.e. negative feelings), My teacher would not criticize me privately	
		If I have the feelings mentioned above (i.e. negative feelings), My teacher would try to help me	How much do you agree with the following statements (1 strongly disagree, 2 somewhat disagree, 3 somewhat agree, 4 strongly agree)
		If I have the feelings mentioned above (i.e. negative feelings), My teacher would ask my parents to help me together	
	Class atmosphere	My class has a good atmosphere	Same as above
		Fraction of classmates NEVER repeating a grade in primary school	The survey asked each student's class progression history in primary school, then authors calculated peer fractions.
	Friends Academic Index	Friends: Doing well in academic performance	How many of your best friends fit in the following description? (1 none of them, 2 one or two of them, 3 most of them)
		Friends: Studying hard	
	Friends skipping class	Friends: Expecting to go to college	
		Friends: Skipping classes	
	Friends' other behaviors violating school rules	Friends: Dropped out of school	
		Friends: Criticized or punished for violating school rules	
		Friends: Always fighting with others	
		Friends: Smoking or drinking alcohol	
		Friends: Always going to net bars or video arcade	
		Friends: Having had or is having a romance	

Notes: This table provides the individual components of each index variable used in the mechanism analysis (Table 6). We aggregate the components into different categories following the aggregation approach by Anderson et al. (2008).

Appendix Table 4. Mechanisms: detailed table with all individual outcomes

Panel A: Student behavior and effort								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Cursing or saying swearwords	Quarreling with others	Having a fight with others	Bullying the weak	Having a violent temper	Unable to concentrate on one thing	Skipping classes	Smoking or drinking alcohol
<i>Peer KG</i>	-0.412*	-0.185	-0.411***	-0.290**	-0.405**	-0.238	-0.163	-0.361***
	(0.217)	(0.180)	(0.121)	(0.114)	(0.196)	(0.203)	(0.100)	(0.066)
	[0.097]	[0.302]	[0.003]	[0.027]	[0.077]	[0.262]	[0.124]	[0.000]
Obs.	3600	3599	3596	3600	3599	3585	3600	3604
R2	0.104	0.080	0.112	0.054	0.053	0.081	0.081	0.046
Panel B: Student socio-emotional abilities								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Usually I can recover from negative feelings soon by myself	Usually I can recover from negative feelings with the help of others	I'm not shy	Usually I would join others rather than sit alone	I often talk when I'm with schoolmates	I can chat with adults easily	There are some adults I respect and admire	I would apologize if I hurt others unintentionally
<i>Peer KG</i>	0.104	0.168	-0.202	0.404**	-0.083	0.867***	0.592**	0.486***
	(0.155)	(0.168)	(0.152)	(0.179)	(0.197)	(0.156)	(0.279)	(0.133)
	[0.552]	[0.435]	[0.405]	[0.089]	[0.673]	[0]	[0.094]	[0.001]
Obs.	3599	3595	3599	3589	3591	3589	3590	3584
R2	0.071	0.059	0.063	0.047	0.041	0.085	0.074	0.061
Panel C: Tools and teacher-student interactions								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Multimedia in teaching	Total working hours	Discussion and Interactions	Hours of comm. btw homeroom teacher & students	My teacher would not ignore and isolate me	My teacher would not criticize me in public	My teacher would not criticize me privately	My teacher would try to help me
<i>Peer KG</i>	0.066	-1.913	0.040	-0.109	0.679***	0.991***	0.045	0.379

Panel A: Student behavior and effort								
	(0.316)	(11.291)	(0.286)	(0.983)	(0.152)	(0.156)	(0.174)	(0.231)
	[0.911]	[0.911]	[0.911]	[0. 911]	[0]	[0]	[0.911]	[0.227]
Obs.	3681	3681	3681	3439	3592	3594	3593	3591
R2	0.847	0.785	0.839	0.724	0.060	0.070	0.059	0.080
Panel D: The characteristics of friends/peers								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Peer fraction of NEVER repeating a grade in primary school	My class has a good atmosphere	Friends: Doing well in academic performance	Friends: Studying hard	Friends: Expecting to go to college	Friends: Skipping classes	Friends: Dropped out of school	Friends: Criticized or punished for violating school rules
Peer KG	0.223***	0.996***	0.267*	0.375**	0.574***	-0.226**	-0.089	-0.303***
	(0.060)	(0.313)	(0.151)	(0.175)	(0.141)	(0.089)	(0.055)	(0.093)
	[0.001]	[0.004]	[0.091]	[0.045]	[0.001]	[0.020]	[0.111]	[0.003]
Obs.	3595	3595	3573	3568	3563	3570	3569	3573
R2	0.954	0.166	0.097	0.130	0.145	0.085	0.057	0.100

Notes: Robust standard errors clustered at the class level are shown in parentheses. We report the adjusted p -values in square brackets to address the concern on multiple hypotheses testing (Simes 1986).

Appendix Table 5. Checking for systematic differences in teacher characteristics

	(1)	(2)	(3)	(4)	(5)	(6)
	Homeroom teacher's teaching experience (years)	Homeroom teacher has province- level award	Homeroom teacher has city-level award	Homeroom teacher has county-level award	Homeroom teacher has school-level award	Age of homeroom teacher
<i>Peer KG</i>	17.361*	0.254	0.336	1.081	0.342	11.780
	(8.636)	(0.410)	(0.621)	(0.831)	(0.930)	(7.036)
Observations	3634	3634	3634	3634	3634	3634
R-squared	0.666	0.606	0.480	0.444	0.431	0.699
	(7)	(8)	(9)	(10)	(11)	
	Homeroom Teacher female	Homeroom teacher edu: Adult higher education	Homeroom teacher edu: College	Homeroom Teacher graduated from	Homeroom teacher's professional title in teaching	

	(7)	(8)	(9)	(10)	(11)
			education or higher	a normal university	
<i>Peer KG</i>	0.857	-0.287	-0.324	-0.047	1.265
	(0.866)	(1.032)	(0.303)	(0.163)	(1.074)
Observations	3634	3634	3634	3634	3634
R-squared	0.524	0.568	0.486	0.460	0.634

Notes: All regressions include a full set of control variables as in Table 4. Standard errors clustered at the class level are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Appendix Table 6. Results from using the aggregations index developed in Kling et al. (2007)

	(1)	(2)	(3)	(4)
	Academic performance	Non-cognitive outcomes	Social adjustment	Mental health
<i>Peer KG</i>	0.624**	0.346**	0.523***	0.276
	(0.301)	(0.164)	(0.117)	(0.206)
Control Mean	0.034	0.026	0.049	0.017
Observations	3641	3606	3606	3603
R-squared	0.408	0.116	0.254	0.072
School FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Notes: The dependent variables include the same set of variables as in the main results, but aggregated using the method developed by Kling et al. (2007). We first normalize each index to have a mean zero and standard deviation of one, then take the simple average of the normalized variables. All regressions include a full set of control variables as in the last column of Table 4. Standard errors clustered at the class level are shown in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Appendix Table 7. Assessing robustness to the addition of other peer characteristics

	(1)	(2)	(3)	(4)
Dep. Var.: Academic Index				
<i>Peer KG</i>	0.753***	0.710**	0.701**	0.698**
	(0.276)	(0.318)	(0.322)	(0.322)
Attended kindergarten	0.193***	0.193***	0.192***	0.192***

	(1)	(2)	(3)	(4)
	(0.041)	(0.041)	(0.041)	(0.041)
Fraction of Peers from a poor family	-1.455***	-1.394***	-1.274***	-1.333***
	(0.359)	(0.357)	(0.400)	(0.430)
Fraction of Peers' mother with high school		0.209	0.068	0.135
		(0.412)	(0.461)	(0.477)
Fraction of Peers' father with high school			0.285	0.412
			(0.370)	(0.351)
Fraction of classroom peers having rural Hukou				0.233
				(0.228)
School FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Dep. Var. Mean	0.056	0.056	0.056	0.056
R-squared	0.406	0.407	0.407	0.407
Observations	3634	3634	3634	3634

Notes: The dependent variable in all columns is an overall index of academic performance that aggregates the test scores of three main subjects (Chinese, math and English) (following the method by Anderson 2008). Regressions include all controls as in the last column of Table 4. Standard errors clustered at the class level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Appendix Table 8. Assessing robustness to the addition of other peer characteristics

	(1)	(2)	(3)	(4)
Dep. Var.: Non-cognitive index				
<i>Peer KG</i>	0.790***	0.579***	0.573***	0.572***
	(0.199)	(0.192)	(0.195)	(0.196)
Attended kindergarten	0.099**	0.096**	0.095**	0.095**
	(0.042)	(0.041)	(0.042)	(0.042)
Fraction of Peers from a poor family	0.183	0.485	0.547	0.505
	(0.350)	(0.363)	(0.373)	(0.385)
Fraction of Peers' mother with high school		1.013***	0.939***	0.987***
		(0.201)	(0.237)	(0.243)
Fraction of Peers' father with high school			0.151	0.253
			(0.252)	(0.288)

	(1)	(2)	(3)	(4)
Fraction of classroom peers having rural Hukou				0.184
				(0.219)
School FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Dep. Var. Mean	0.090	0.090	0.090	0.090
R-squared	0.227	0.229	0.229	0.229
Observations	3437	3437	3437	3437

Notes: The dependent variable in all columns is an overall index of non-cognitive performance that aggregates from two dimensions: mental stress and social adjustment (following the method by Anderson 2008). Regressions include all controls as in the last column of Table 4. Standard errors clustered at the class level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

1. The full text of the policy is available at:
https://www.gov.cn/gongbao/content/2003/content_62048.htm
2. Retrieved from: http://www.cycrc.org.cn/kycg/qnzyjs/202210/t20221028_114157.html
3. Results from the disaggregated test scores are similar. Results remain unaltered even when we create the overall z-score index following Kling et al. (2007), Deming (2009), and Xu et al. (2022).
4. The original question in the survey is whether students agree school life is boring. We reverse the order so that higher values indicate more school engagement.
5. In China, universities designated as "Normal" often focus on teacher education and training. The term "normal" originates from the French "école normale," which historically referred to organizations focused on establishing and promoting educational norms and standards.
6. Parent's college completion indicators are used in the heterogeneity analyses alone.