Annenberg Institute
BROWN UNIVERSITY

EdWorkingPaper No. 24-1052

Falling Behind as Peers Age Up: The Effects of Peer Age on Student Cognitive and Non-Cognitive Outcomes

Xiao Liu
Nanjing Audit University

Chuanyi Guo
University of Kentucky

Han Yu
University of Memphis

Understanding the factors that influence student outcomes is crucial for both parents and schools when designing effective educational strategies. This paper explores the impact of peer age on both cognitive and non-cognitive outcomes using a randomized sample of middle school students. By analyzing how exogenous variations in peer age affect students' academic performance, self-expectations and confidence, health perceptions, behavioral traits, and social development, we highlight the important role that peer age plays in educational contexts. Our findings reveal that an increase in the average age of classmates results in negative effects on both cognitive and non-cognitive outcomes of a student. We also identify significant heterogeneous effects based on student relative age and gender. We delve into potential mechanisms behind these effects and study inputs from the perspective of student themselves, parents, teachers, and the school within the framework of the education production function. The results suggest that students' persistence in their studies, the quality of friendships, and the school environment they are exposed to are the primary drivers of our main findings. These findings underscore the importance of addressing age disparities within classrooms to enhance students' cognitive and non-cognitive development.

VERSION: October 2024

Suggested citation: Liu, Xiao, Chuanyi Guo, and Han Yu. (2024). Falling Behind as Peers Age Up: The Effects of Peer Age on Student Cognitive and Non-Cognitive Outcomes. (EdWorkingPaper: 24-1052). Retrieved from Annenberg Institute at Brown University: https://doi.org/10.26300/m0s2-zw27

Falling Behind as Peers Age Up: The Effects of Peer Age on Student Cognitive and Non-Cognitive Outcomes*

Xiao Liu Chuanyi Guo Han Yu

September 16, 2024

Abstract

Understanding the factors that influence student outcomes is crucial for both parents and schools when designing effective educational strategies. This paper explores the impact of peer age on both cognitive and non-cognitive outcomes using a randomized sample of middle school students. By analyzing how exogenous variations in peer age affect students' academic performance, self-expectations and confidence, health perceptions, behavioral traits, and social development, we highlight the important role that peer age plays in educational contexts. Our findings reveal that an increase in the average age of classmates results in negative effects on both cognitive and non-cognitive outcomes of a student. We also identify significant heterogeneous effects based on student relative age and gender. We delve into potential mechanisms behind these effects and study inputs from the perspective of student themselves, parents, teachers, and the school within the framework of the education production function. The results suggest that students' persistence in their studies, the quality of friendships, and the school environment they are exposed to are the primary drivers of our main findings. These findings underscore the importance of addressing age disparities within classrooms to enhance students' cognitive and non-cognitive development.

Keywords: Peer Age, Human Capital Accumulation, Random Assignment
JEL: D91, I12, I21, I24, J24

*Authorship is equally shared. We thank Andrew Hussey and Naci Mocan for useful comments. All errors are our own. Xiao Liu (Email: liu.xiao@nau.edu.cn), Institute of Economics and Finance, Nanjing Audit University, Nanjing, Jiangsu Province 211815, China. Chuanyi Guo (Email: chuanyi.guo@uky.edu), Martin School of Public Policy and Administration, University of Kentucky, Lexington, KY 40506, USA. Han Yu (Corresponding author. Email: han.yu@memphis.edu), Department of Economics, University of Memphis, Memphis, TN 38152, USA.

1. Introduction

How peers shape individual outcomes has garnered considerable attention from researchers and has been widely addressed in the literature. Peer effects, broadly understood as the effects of peers on individuals' performance, behavior, attitudes, and beliefs within the same network, have been extensively investigated across various contexts, including education, labor markets, financial markets, sports, crime, and social networks (e.g., Black, Devereux, and Salvanes, 2013; Burke and Sass, 2013; Bursztyn et al., 2014; Damm and Gorinas, 2020; Guryan, Kroft, and Notowidigdo, 2009; Mocan and Osborne-Christenson, 2022; Olivetti, Patacchini, and Zenou, 2020; Zimmerman, 2003). This rich body of work underscores the multifaceted nature of peer effects and their pervasive impact on a wide array of individual behaviors and outcomes.

In particular, numerous studies have demonstrated the critical role of peers in determining student outcomes. For instance, prior research has shown that being surrounded by peers with disruptive backgrounds could harm students' academic performance, reduce their future income prospects, and raise their likelihood of engaging in misbehavior (e.g., Ahn and Trogdon, 2017; Carrell and Hoekstra, 2010; Carrell, Hoekstra, and Kuka, 2018; Carrell, Malmstrom, and West, 2008). On the other hand, exposure to peers who exhibit positive attributes, such as good behavior, persistence in study, or advantageous backgrounds, often leads to improvements in both academic and non-academic achievement (e.g. Golsteyn, Non, and Zölitz, 2021; Michelman, Price, and Zimmerman, 2022; Shure, 2021). Moreover, the literature has delved into the impact of students' peer demographics such as gender, ethnicity, country of origin, and disability status (e.g., Balestra, Eugster, and Liebert, 2022; Brenøe and Zölitz, 2020; Carlana, La Ferrara, and Pinotti, 2022; Costas-Fernández, Morando, and Holford, 2023). Another substantial branch of the literature focuses on the effects of peers' ability. Studies in this area document mixed evidence on the impact of high-achieving peers (e.g., Antecol, Eren, and Ozbeklik, 2016; Burke and Sass, 2013; Carrell, Fullerton, and West, 2009; Duflo, Dupas, and Kremer, 2011; Lavy, Silva, and Weinhardt, 2012).[1]

[1]Particularly, the relationship could be non-linear and depend on the student's relative standing within the peer group. See Antecol, Eren, and Ozbeklik (2016), Elsner and Isphording (2017), Murphy and Weinhardt (2020), and Yu (2020) for recent studies that document the effects of a student's ordinal rank.

Despite the wealth of research highlighting the importance of various attributes of peers in affecting student outcomes, the effect of peer age remains surprisingly underexplored. To our knowledge, no existing studies have directly investigated the causal impact of peer age on the achievement of students. In this paper, we fill this gap in the literature by providing direct evidence of the causal effect of peer age on student cognitive and non-cognitive outcomes.[2] Importantly, the influence of peer age may manifest through several pathways. For example, older peers in the same classroom may exhibit more advanced cognitive skills, which provides a role model for younger students to emulate; meanwhile, they may also foster feelings of academic pressure. Moreover, older students may often take on leadership roles or dominate classroom interactions (e.g., Dhuey and Lipscomb, 2008; Fumarco and Baert, 2019). This could influence younger students' self-perceptions and engagement in academic and social activities. In addition, differences in emotional and behavioral development across age groups could affect the classroom environment. They may affect students' ability to collaborate, learn effectively, and develop interpersonal skills. These factors eventually affect students' cognitive and non-cognitive achievement.

In this paper, using a nationally representative sample of Chinese middle school students who were randomly assigned to classrooms and peers at the start of 7th grade, we exploit the exogenous variation in peers' middle school entry age and investigate how changes in peer age affect a student's cognitive ability and academic performance in math, Chinese, and English in middle school.[3] Furthermore, we extend the analysis to students' non-cognitive outcomes, including self-expectations and confidence, health-related outcomes and behaviors, as well as social behavior and development.

Our identification strategy relies on the random composition of peers determined for each student upon entering middle school. Since peers were randomly assigned and pre-determined, each student confronts an idiosyncratic mean of peer age that is strictly exogenous. Particularly, this approach eliminates concerns related to student sorting and the reflection problem identified by Manski (1993). We therefore are able to isolate exogenous

[2]Age differences among students in the same learning environment often stem from a multitude of factors, including school admission regulations, intentional parental choices such as redshirting or greenshirting, and instances of grade repetition or advancement.

[3]In our context, the variation in treatment arises from students' age at the time of entering middle school, which we refer to interchangeably as "school entry age" or simply "age" throughout the discussion.

variations in peer age and draw causal inferences about the relationship between peer age and students' outcomes of interest. Our findings are robust across various specifications that account for student characteristics, family background, teacher attributes, and other peer features at the classroom level. It is also important to consider that the effect of peer age could be non-linear depending on the student's position relative to the average peer age in the classroom. To investigate this, we analyze potential heterogeneous effects for students who are either younger or older than their peers. In addition, we examine gender differences in the effects of peer age, as boys and girls may respond differently due to variations in socialization, developmental trajectories, and peer interactions.

The main findings of this paper are fourfold. First, we find that peer age has statistically significant negative effects on students' academic performance in math, Chinese, English, and overall cognitive ability. Specifically, a one-standard deviation increase in the average age of peers reduces these test scores substantially by roughly one third of a standard deviation. Second, our results demonstrate that peer age exerts notable negative effects on students' non-cognitive outcomes. For instance, an increase in the average peer age significantly lowers students' expectations of attaining a college degree or higher, securing a gold- or white-collar job, and living in first-tier cities or abroad. Additionally, students exhibit lower self-confidence, particularly in self-perceived physical attractiveness. We observe similar adverse effects on students' virtuous behaviors and social development, though peer age does not appear to influence health-related perceptions or behaviors. Third, we document heterogeneous effects based on students' relative age and gender. Students who are younger than their classroom peers benefit from improved overall health and mental well-being as peer age increases, while older students exhibit reduced virtuous behaviors and worse social development. Additionally, male students appear more vulnerable to the negative effects of peer age in subjects like Chinese and English, whereas peer age enhances the mental health of female students but not male students. Fourth, our findings reveal that peer age negatively affects both cognitive and non-cognitive skills primarily through its effects on students' persistence in study, the quality of their friendships, and the social climate at school. In contrast, we find little evidence that teachers' behaviors or family investments play a meaningful role in mediating these peer age effects.

This study contributes to three distinct strands of literature. First, and broadly, we advance the extensive research on peer effects in the education setting from two major aspects. To our knowledge, we are the first to identify the causal impact of peer age on student outcomes. Given the significance of peer age as a peer attribute, it is crucial to understand its influence on student performance. Moreover, we expand the scope of this analysis beyond cognitive outcomes to include a wide range of non-cognitive factors that are usually not covered in previous research. This offers a more comprehensive understanding of how peer age affects students from multiple dimensions.

Second, our research adds to the growing body of literature on the effects of student relative age. Identifying the causal effect of relative age poses significant empirical challenges, such as self-selection biases due to intentional manipulation of school entry age by parents.[4] We address these identification problems by leveraging random variation in students' peer age. While our treatment variable does not directly measure relative age, our analysis provides insights into its impact. Specifically, we examine peer age effects by comparing students with identical middle school entry ages but different peer ages that are purely random. This approach ensures that, conditional on the student's own age, the relative age—the difference between the student's age and that of their peers—is also random. Our findings offer valuable evidence on the role of relative age in shaping student outcomes, which we further explore in the effect heterogeneity section of this paper.

Third, we deepen our contribution to the literature on the education production function by exploring a rich set of potential mechanisms through which peer age may affect student outcomes.[5] Utilizing extensive data on perceptions and behaviors of students, parents, teachers, and the school, we identify five channels: students' own effort and

[4]To address these issues, some studies use an instrumental variable approach. Specifically, they instrument relative age with "expected" or "assigned" relative age calculated based on a student's birth date relative to the school entry cutoff date (e.g., Bedard and Dhuey, 2006; Black, Devereux, and Salvanes, 2011; Cascio and Schanzenbach, 2016; Datar, 2006; Dhuey and Lipscomb, 2008; Elder and Lubotsky, 2009; Mühlenweg and Puhani, 2010). This approach, however, has been criticized for potentially violating the monotonicity assumption (Barua and Lang, 2016; Peña, 2017). Other studies employ a regression discontinuity design (e.g., Cook and Kang, 2016; Dhuey et al., 2019; Dobkin and Ferreira, 2010; Fredriksson and Öckert, 2014; Guo, Wang, and Meng, 2023; McEwan and Shapiro, 2008). They rely on the key assumption that there is no precise manipulation of birth dates right around the school entry cutoff. However, this assumption may be violated in some contexts (Shigeoka, 2015).

[5]See Hanushek (1979) for a detailed review of the education production function.

persistence in study, the quality of friendships, family investments, teacher inputs, and the social environment at school. By examining these diverse mechanisms, we provide a comprehensive understanding of how peer age interacts with educational inputs and influences student achievement. This approach not only advances theoretical insights into peer age effects but also provides practical implications for educational policy and practice.

The remainder of the paper proceeds as follows. In Section 2, we briefly introduce the institutional background for this study and the data. Section 3 discusses the identification strategy, validity of the randomization, and the empirical model. We then present our main findings and discuss underlying mechanisms of the estimated peer age effects in Section 4. Section 5 concludes.

2. Institutional Background and Data

2.1. Institutional Background

The compulsory education in China consists of six years of primary education covering 1st grade to 6th grade, followed by three years of middle school education spanning 7th grade to 9th grade. Upon completion of primary school (at the conclusion of 6th grade), students transition to state-operated middle schools, typically based on their *hukou*.[6] At the start of 7th grade, students are placed into classrooms where they generally remain with the same group of peers and follow a consistent curriculum for the three years of middle school until graduation. Since middle schools typically draw students from multiple primary schools, it is uncommon for former primary school classmates to be placed in the same middle school class. As a result, students often find themselves with mostly new peers when they enter 7th grade. All middle school students are required to study three core subjects—math, Chinese, and English—along with a range of additional subjects such as physics, biology, chemistry, history, and geography.[7]

[6] *Hukou* can be understood as an individual's residency status. For middle school students, their *hukou* determines the middle schools they are eligible to attend.

[7] Math, Chinese, and English are particularly important subjects because they carry the highest weight in the high school entrance exam (also known as the *Zhongkao*), which plays a decisive role in determining the high school a student can attend.

Middle schools in China implement a homeroom teacher system that is designed to provide students with a supportive environment throughout the school day. Under this system, students remain in their designated homeroom classroom for the duration of the school day, while subject teachers rotate to teach different classes. This arrangement allows students to form close bonds not only with their classmates but also with their homeroom teacher who serves as a mentor and guide throughout their middle school years. It provides a sense of stability and familiarity, nurturing students' academic, social, and emotional development.

Since 2006, the Ministry of Education has mandated a policy that prohibits classroom assignments based on demonstrated ability or academic performance. As a result, an increasing number of schools have adopted random assignment algorithms to place students in classrooms. Middle schools typically use random assignment to allocate students to homeroom classrooms at the start of 7th grade. This approach ensures a diverse student composition and promotes equal opportunities for students to interact with peers from various socioeconomic, cultural, and academic backgrounds. This fosters an inclusive learning environment where students can benefit from each other's diverse perspectives and experiences. In this paper, we focus on schools that randomly assign 7th-grade students to classrooms upon entry into middle school, which eliminates concerns about student sorting and the reflection problem. In Section 3, we formally assess the validity of the randomization of students in the data.

2.2. Data and Descriptive Statistics

We utilize data from the China Education Panel Survey (CEPS), the first and largest nationally representative longitudinal survey that focuses on middle school students in China. The CEPS sample consists of a random selection of 438 classrooms from 112 schools across 28 districts, counties, or cities. The survey employs a stratified, multistage sampling design. In the first stage, 28 counties or districts were selected from a total of 2,870 across the nation. Within each area, four schools were then randomly selected to participate. Subsequently, two 7th-grade classrooms and two 9th-grade classrooms were randomly selected from each school. All students in these selected classrooms were surveyed

during the first wave of the CEPS in the 2013-2014 academic year. A follow-up survey was then conducted with the 7th-grade students in the 2014-2015 academic year. The CEPS administers four questionnaires targeting (i) students, (ii) parents, (iii) teachers, and (iv) school administrators, respectively. The dataset contains a wealth of information on students' cognitive and non-cognitive performance, demographics, family background, and teachers' characteristics. Moreover, it encompasses data on perceptions and behaviors of students, parents, and teachers, along with information about the school environment. These data provide valuable insights into mechanisms underlying the effects on student outcomes.

In this paper, we leverage data from students who entered 7th grade in the 2013-2014 academic year and have information available from both waves of the CEPS. This enables us to investigate the impact of peers' middle school entry age on students' cognitive and non-cognitive outcomes measured in 8th grade (the second wave), and to explore an extensive array of potential mechanisms gauged in 7th grade (the baseline wave). To conduct our analysis, we restrict the sample to schools that randomly assigned 7th-grade students to classrooms when they entered middle school. To identify these schools, we follow the literature and adopt criteria similar to those used by Xu, Zhang, and Zhou (2022). Specifically, out of the 112 sampled schools, 83% (N = 93) of school administrators reported that students were randomly assigned to classrooms at the start of middle school, resulting in a sample of 8,483 students across 183 classrooms. We then narrow our sample to include only 7th-grade students who were successfully tracked into 8th grade and stayed in the same classroom throughout the academic year.[8] Additionally, we drop observations with missing information on student and teacher characteristics. Our final working sample includes 5,177 students across 151 classrooms in 80 schools.[9]

Table 1 presents summary statistics for the main variables, including students' cognitive

[8]We provide supporting evidence in Appendix Table A1 that sample attrition, due to students dropping out of the CEPS survey or changing classrooms, is unlikely to bias our results. We test whether peers' middle school entry age affects the likelihood of sample attrition and find that the estimated coefficient on peer age is close to zero and statistically insignificant. This indicates that attrition is not systematically related to our treatment, suggesting that our main results are not affected by sample attrition.

[9]In Section 3.1, we implement a series of tests and present evidence demonstrating that students in our sample were indeed randomly assigned to classrooms at the beginning of 7th grade. All the randomization tests were conducted at the block level, with each block representing a distinct grade within a given school. Given that our research only focuses on 7th-grade students, each block corresponds to a specific school in our context.

and non-cognitive outcomes, their peer and own middle school entry age, and other individual-level covariates. In our sample, 49% of students are female, and around 9% belong to minority ethnic groups. 74% of the sample students are local residents and 45% come from rural areas. 84% of the students have attended kindergarten before starting primary school. Additionally, approximately one-fifth of students' parents hold a college degree or higher, and about one-third are employed in blue-collar occupations.

We evaluate both cognitive and non-cognitive performance of students in this study. Cognitive outcomes are assessed in 8th grade using mid-term exam scores in math, Chinese, and English, as well as a cognitive ability measure.[10] All teachers instructing the same subject in the same grade within a particular school follow a uniform syllabus. All students in the same grade of a school take the same mid-term exam during a common testing period. Therefore, students' test scores are comparable within each grade at a given school. To facilitate interpretation, we standardize these scores at the school-grade level to have a mean of zero and a standard deviation of one.

We investigate three sets of non-cognitive outcomes observed in 8th grade. The first set focuses on students' self-expectations and confidence. Surveyed students were asked about their expectations regarding educational attainment, career choices, and future residential locations. Based on their responses, we construct three dummy variables indicating whether a student expects to obtain at least a college degree, harbors strong career aspirations towards pursuing gold-collar or white-collar professions, and intends to reside in first-tier cities in China (such as Beijing, Shanghai, and Guangzhou) or abroad.[11] Moreover, we employ two variables to evaluate students' self-confidence. First, to gauge the overall level of

[10]The cognitive ability test is designed to evaluate students' logical thinking and problem-solving skills across three dimensions: (1) language, (2) graphics and space, and (3) computation and logic. Administered in class by the homeroom teacher and the CEPS, this standardized test assigns a cognitive ability score to each student. Higher scores indicate better cognitive ability.

[11]The CEPS surveys collected data on students' anticipated highest level of education. We construct a dummy variable set to one if a student expects to attain at least a college degree in the future and zero otherwise. Another survey question captured students' career expectations. We create a dummy variable that takes a value of one if a student anticipates career paths such as civil servants, government officials, corporate executives, scientists, engineers, doctors, programmers, pilots, astronauts, teachers, lawyers, accountants, translators, professional designers, or artists; otherwise, the variable is assigned a value of zero. Additionally, students were asked about their preferred future living locations. We create a dummy variable that equals one if a student expects to reside in first-tier cities in China (such as Beijing, Shanghai, and Guangzhou) or abroad; otherwise, the variable is set to zero. These three variables reflect students' self-expectations related to education, career, and living environment, respectively.

self-confidence, we establish an index derived from three survey questions by averaging the responses of students on a 4-point scale ranging from 1 ("strongly disagree") to 4 ("strongly agree").[12] A higher score on this index indicates a higher level of self-confidence. Second, the CEPS provides unique data on students' perceived attractiveness. Specifically, students were asked to rate their physical appearance on a 5-point scale from 1 ("very ugly") to 5 ("very good-looking"). We create a dummy variable that equals one if students perceive themselves as "*very good-looking*", identifying individuals with strong self-confidence in their physical appearance. This variable is important given the extensive literature that documents the influential role of physical attractiveness in shaping individual outcomes and behaviors such as academic performance, productivity, electoral success, financial decisions, and earnings (see, for example, Berggren, Jordahl, and Poutvaara, 2010; Cipriani and Zago, 2011; Duarte, Siegel, and Young, 2012; Mobius and Rosenblat, 2006; Persico, Postlewaite, and Silverman, 2004). These studies highlight self-confidence as a crucial underlying mechanism in these relationships.

The second set of non-cognitive outcomes explores students' health-related outcomes. First, students rated their overall health condition on a scale from 1 ("very poor") to 5 ("very good") in the survey. We construct an indicator that takes a value of one if students perceive their overall health as "*good*" or "*very good*". Second, to assess students' mental health, we create a composite index based on the average rating of ten distinct questions regarding students' mental state over the past seven days.[13] Higher values on this index indicate poorer mental health conditions. Last, we create variables to measure students' health-related behaviors. We construct a binary variable to signify students' engagement in health-enhancing activities, set to one if students participate in weekly physical exercise and zero otherwise. To evaluate students' health-compromising behaviors, we use two dummy

[12]The three survey questions are: (1) "I will attempt to explore alternative problem-solving approaches if my initial method is inappropriate"; (2) "I can stay calm even in bad situations"; (3) "I usually have confidence in my ability to complete the tasks that need to be done."

[13]The CEPS asked students to evaluate their emotional states over the past week by indicating their level of agreement with a series of statements. The ten survey items are listed as follows: (1) "I felt depressed"; (2) "I felt too downhearted to concentrate"; (3) "I felt unhappy"; (4) "I felt that life was meaningless"; (5) "I felt unmotivated to do things"; (6) "I felt sad and upset"; (7) "I felt nervous"; (8) "I felt excessively worried"; (9) "I felt that something bad would happen"; (10) "I felt overly energetic and could not focus in class". Responses were recorded on a 5-point scale from 1 ("never") to 5 ("always"). We use students' responses to these ten statements to measure their mental health status.

variables. One variable indicates whether students frequently consume unhealthy food (e.g., fried, grilled, or puffed food), while the other denotes regular intake of unhealthy beverages (e.g., sugary drinks or sodas). Both variables are assigned a value of one if students reported "*often*" or "*always*" engaging in these behaviors.

The third category of non-cognitive outcomes comprises three variables that evaluate students' social behaviors and development. First, virtue is recognized as a pivotal behavioral trait highly valued in society (Heckman, Galaty, and Tian, 2023). We construct a virtuous behavior index derived from the average rating of students' responses to three questions concerning their altruism and adherence to virtue ethics.[14] Higher scores on this index reflect a stronger commitment to moral excellence. Second, we create an index of disruptive behaviors by averaging responses to ten survey items related to disciplinary issues.[15] Higher scores on this index indicate greater involvement in problematic behaviors. Similarly, we build another index to gauge students' maturity and social development based on survey items related to social interaction and interpersonal growth.[16] A higher value of this index signifies a higher level of social development.

3. Empirical Strategy

3.1. Identification and Validity of Random Assignment

In this paper, we investigate the causal impact of peers' middle school entry age on student outcomes. A major challenge in studying peer effects is the absence of random

[14]The three behaviors assessed are: (1) helping the elderly, (2) obeying rules and queuing conscientiously, and (3) being sincere and friendly to others. Students reported their frequency of engaging in these behaviors on a 5-point scale from 1 ("never") to 5 ("always").

[15]These disruptive behaviors include: (1) insulting or cursing, (2) quarreling, (3) fighting, (4) bullying, (5) having a bad temper, (6) lacking concentration, (7) skipping classes or playing truant, (8) plagiarizing homework or cheating on exams, (9) smoking or drinking alcohol, and (10) frequenting internet cafes or game arcades. Responses to these survey questions were collected on a 5-point scale from 1 ("never") to 5 ("always").

[16]There are six statements in this series of survey questions. They are: (1) "I am very shy"; (2) "I often sit alone and prefer not to be with others"; (3) "When I stay with my classmates or friends, I don't talk much and mostly listen to them"; (4) "There are some adults I respect and admire"; (5) "I can chat easily with adults"; (6) "When I hurt or offend someone unintentionally, I apologize". Responses to these statements were recorded on a 4-point scale from 1 ("strongly disagree") to 4 ("strongly agree"). To ensure consistency, we recode responses to statements (1)–(3) so that higher values indicate greater social development, aligning with statements (4)–(6). We then calculate the index by averaging a student's responses to all six statements.

peer assignment, which can lead to endogeneity issues as individuals tend to self-select their peers. To address this potential source of bias, our study uses a sample of students who have been randomly assigned to classrooms within school-grade blocks. This allows us to compare students of the same school entry age but exposed to different, randomly assigned peer age compositions across classrooms at the school-grade level. This introduces exogenous variations in average peer age, providing a compelling basis for identifying causal relationships in our analysis.

To examine the validity of the random assignment of students in our data, we implement two separate sets of tests. First, we closely follow Guryan, Kroft, and Notowidigdo (2009) and estimate the following equation:[17]

$$SEA_{icb} = \pi_0 + \pi_1 \overline{SEA}_{-i,cb} + \pi_2 \overline{SEA}_{-i,b} + \theta_b + \varepsilon_{icb} \tag{1}$$

where SEA_{icb} is the middle school entry age (i.e., the age at which the student started 7th grade) for student i in classroom c of school-grade block b. $\overline{SEA}_{-i,cb}$ signifies the leave-out mean of peer entry age in classroom c of block b excluding the age of student i. $\overline{SEA}_{-i,b}$ denotes the leave-out mean of peer entry age in block b. In addition, the regression controls for a set of school-grade block fixed effects, denoted by θ_b. ε_{icb} represents the error term. The rationale behind this approach is that, in a setting of random assignment, the age at which a student enters middle school should bear no correlation with the average entry age of their peers within the same classroom. The estimated coefficient $\hat{\pi}_1$ under this circumstance would be statistically indistinguishable from zero. The findings from our randomization test, as detailed in Table 2, support this assumption. We find that the coefficient of classmates' average age (see Column 2) is insignificant and very close to zero in magnitude. This provides evidence that there is no statistically significant correlation between a student's own age at middle school entry and the corresponding entry age of their peers.

[17] As shown in Guryan, Kroft, and Notowidigdo (2009), in a truly random setting, the mechanical relationship between own outcome and the mean outcome of randomly assigned peers can introduce biases. The problem stems from the fact that individuals cannot be assigned to themselves as peers, and it can be addressed by controlling for the leave-out mean of all other individuals in the block. See Antecol, Eren, and Ozbeklik (2016), Brenøe and Zölitz (2020), and Guryan, Kroft, and Notowidigdo (2009) for detailed discussions and examples of applications of this well-behaved randomization test.

Moreover, we investigate whether the assignment of teachers and students across classrooms within school-grade blocks is random based on observable characteristics of teachers and students. Specifically, we explore the relationship between the average middle school entry age in a classroom and a comprehensive set of characteristics pertaining to both the homeroom teacher and students. We conduct the analysis at the classroom level and present the results in Table 3. Columns 1 and 2 report the results excluding and including block fixed effects, respectively. In addition, we report the F-statistics derived from the joint significance test at the bottom of the table. The results clearly show that, after accounting for block fixed effects, none of the coefficients are statistically significant. Furthermore, the F-statistic in Column 2 indicates joint insignificance across these characteristics. These results document that teacher and student attributes are well balanced across classrooms, thereby further validating the random assignment in our dataset.

Another challenge in identifying the causal impact of one's peers is Manski's reflection problem (Manski, 1993). The issue arises when it is difficult to specify a pre-established reference group of peers when analyzing their influence on an individual's outcomes. The complexity stems from the inherent interdependence between the individual and the peer group, as both are exposed to common shocks in the same environment. Consequently, the outcomes of individuals and the explanatory variables related to peers may be determined simultaneously, or there exists reverse causality between the two. In our specific research framework, however, the reflection problem is not a concern. This is mainly because our explanatory variable of interest is the average school entry age of peers upon middle school enrollment. These entry ages are predetermined factors set before classroom assignments and peer group formation. In addition, students' middle school entry ages do not vary due to any shocks that take place within a classroom. As a result, by leveraging this predetermined, and therefore exogenous, age information, we are able to build a solid causal link between peer age and student outcomes.

3.2. Empirical Model

To formally examine the causal effects of peer age on student outcomes, we estimate the following linear-in-means model:

$$Y_{icb} = \beta_0 + \beta_1 \overline{SEA}_{-i,cb} + \beta_2 SEA_{icb} + \beta_3 \overline{SEA}_{-i,b} + \theta_b + X_{icb}\gamma' + T_{cb}\delta' + C_{cb}\lambda' + u_{icb} \quad (2)$$

where Y_{icb} refers to cognitive and non-cognitive outcomes of student i in classroom c of block b. $\overline{SEA}_{-i,cb}$, SEA_{icb}, $\overline{SEA}_{-i,b}$, and θ_b are as previously defined. The coefficient of interest is β_1, which captures the causal impact of peer age on student outcomes. All regressions include a set of block fixed effects. Standard errors are clustered at the block level.

X_{icb} and T_{cb} represent vectors of attributes of student i and the homeroom teacher, respectively. To be specific, student characteristics include the student's gender, ethnicity, status of rural and local residence, single-child status, kindergarten attendance, and family background including parental educational attainment, parental occupations, and family income status before the student started primary school. The homeroom teacher's characteristics include gender, age, teaching experience, educational level, and whether the teacher graduated from a normal university.

Furthermore, we utilize C_{cb} to assess certain peer characteristics at the classroom level that are strictly exogenous in our context. Specifically, C_{cb} includes the classroom size, the proportion of female students, and the proportion of students from high-income families before attending primary school. The latter two variables represent the leave-out means within classroom. It is important to note that a family's economic status serves as a comprehensive proxy for various aspects of a student's background. This includes factors such as family income, parental education and occupations, and family investment in children's development. u_{icb} denotes the error term.

4. Empirical Findings

4.1. Main Results

We present our main findings on the effects of peer age on students' cognitive outcomes, including exam and cognitive ability scores, in Table 4. The results pertaining to students' non-cognitive outcomes, such as self-expectations and confidence, health-related outcomes, as well as behaviors and social development, are reported in Table 5. Each coefficient in Tables 4 and 5 is obtained from a separate regression estimating equation (2).

In Table 4, dependent variables encompass students' test scores in the subjects of math, Chinese, and English, as well as their cognitive ability scores. In Column 1, we present the estimated impacts of peer school entry age on these outcomes, only controlling for the student's own age at middle school entry, the leave-out mean of peer entry age within block, and block fixed effects. In Columns 2 and 3, we gradually add student and homeroom teacher characteristics as additional covariates. It is worth noting that the homeroom teacher's attributes could relate to some potential channels through which peer age affects student outcomes. For instance, a homeroom teacher's teaching experience might be associated with the teacher's behaviors in class that vary with the age composition of students. We delve into such mechanisms later in Section 4.3. In Column 4, we further expand the model by including classroom-level controls that capture additional peer characteristics, with this specification serving as our preferred model.

After controlling for student, homeroom teacher, and classroom peer characteristics, we observe consistent and significant negative effects of peers' average middle school entry age on both academic performance and cognitive ability. Specifically, in Column 4, the results indicate that a one-year increase in peers' average age leads to a decrease of 1.096 standard deviations in students' math scores. This implies that a one-standard deviation increase in the average peer age (approximately four months) causes 0.358 ($= 1.096 \times 0.327$) of a standard deviation reduction in the math score. Similarly, a one-standard deviation increase in peers' average age leads to declines of approximately 0.252 and 0.303 standard deviations in Chinese and English scores, respectively. Additionally, we find that a one-standard deviation

increase in peers' average age results in a 0.379 standard deviation reduction in cognitive ability scores.[18]

Table 5 presents the findings related to non-cognitive outcomes. All regressions utilize our preferred model which includes the full set of covariates outlined in Column 4 of Table 4. Panel A exhibits the estimated effects of peer school entry age on students' self-expectations and confidence. We document negative and statistically significant effects on students' self-expectations (see Columns 1–3). For instance, a one-standard deviation increase in the average peer age leads to approximately a nine percentage point reduction in the likelihood of a student expecting to attain a college degree or higher. This represents a substantial 10.4% decline compared to the mean of the dependent variable. Similarly, we find that a one-standard deviation increase in peers' average age results in a four percentage point reduction (about 5.8% compared to the mean) in the probability of a student anticipating a gold- or white-collar profession, and a six percentage point reduction (around 8.7% compared to the mean) in the likelihood of planning to reside in first-tier cities or abroad. Moreover, our results reveal a notable negative effect on students' self-perceived physical attractiveness. The impact on the self-confidence index is also negative, although less precisely estimated.

In Panel B of Table 5, we assess the impact of peer age on students' health-related perceptions and behaviors. Columns 1 and 2 examine students' self-reported overall health and mental health status, respectively, with the results showing no significant effects. Additionally, the estimated effects on health-related behaviors (Columns 3–5) are small in magnitude and statistically insignificant. Overall, these findings suggest that peer age does not have a substantial influence on students' health-related outcomes in the full sample.

Turning to Panel C, we extend our analysis to explore whether peer age affects students'

[18]It is important to highlight that the magnitude of the cognitive performance effect we observe for peer age is larger than that of many peer effects documented in previous research. For instance, Antecol, Eren, and Ozbeklik (2016) reported that a one-standard deviation increase in peer ability results in a decrease in math and reading test scores by about one-ninth of a standard deviation. Using data from a business school in the Netherlands, Golsteyn, Non, and Zölitz (2021) found that a one-standard deviation increase in average peer persistence raises grades by about 1.8% of a standard deviation. These effect sizes are smaller than our estimates, likely because peer traits such as ability and persistence in those studies typically follow a normal distribution. In contrast, in our context, peer ages within a classroom approximate a uniform distribution. In a normal distribution, values are more concentrated around the mean, so a one-standard deviation change represents a shift within a narrower range of values. However, in a uniform distribution, values are spread more evenly across the range, meaning a one-standard deviation change spans a wider portion of the total range. As a result, the effect of peer age, when expressed in terms of standard deviations, appears larger.

engagement in virtuous behaviors, disruptive behaviors, and social development. The results suggest negative effects on students' moral conduct and social development (see Columns 1 and 3). We also find consistent evidence showing that higher peer age leads to an increased likelihood of disciplinary issues (Column 2), albeit with less precision in estimation.

4.2. Heterogeneous Effects

In this section, we focus on the heterogeneous effects of peer age on all main outcomes examined in Section 4.1. Specifically, we explore differential effects based on age relative to classroom peers' average and student gender, and conduct all estimations using our most inclusive model that controls for the full set of covariates. Relative age, or a student's position within the age distribution of their peers, can influence academic and social development due to differences in maturity, cognitive development, and social interaction with peers. Gender, on the other hand, plays a pivotal role in how students experience peer interactions and educational environments. By studying these heterogeneities, we uncover whether the effects of peer age are more pronounced for certain students and how these factors interact to shape educational outcomes.

4.2.1. By Student Relative Age

We investigate the potential nonlinearities in peer age effects by studying students whose age is below or above the classroom peer age separately. We present the results of cognitive outcomes in Figure 1. Our findings reveal no statistically significant heterogeneity, except for Chinese test scores. To be specific, students older than their peers exhibit a significant negative effect on Chinese test scores, while the effect is negative but insignificant for younger students.

When examining the effects on non-cognitive outcomes by student relative age in the classroom, we do not find significant disparities in students' self-expectations and confidence, except for future living locations (see Figure 2A). Notably, students younger than their classroom peers show a greater tendency to avoid living in first-tier cities or abroad as the age gap increases. However, we do not observe a similar effect among students who are older

than their classroom peers. For health outcomes, as shown in Figure 2B, there are clear differences in self-perceived overall health, mental health, and consumption of unhealthy beverages. Specifically, as peer age increases, students older than their classmates report worse overall health, poorer mental health, and a higher likelihood of consuming unhealthy beverages compared to younger students. Regarding behaviors and social development (see Figure 2C), we find that an increase in peer age leads to less virtuous behavior and diminished social development among students older than their classmates. No such effects are observed among students younger than their peers.

4.2.2. By Gender

Figure 3 presents the effects of peer age on students' test scores in math, Chinese, and English, as well as their cognitive ability scores, separately by gender. The results indicate that the estimated effects on math and cognitive ability scores follow similar patterns for both male and female students. More precisely, these effects are negative and statistically significant across both gender groups. In contrast, we observe diverging effects by gender for test scores in Chinese and English. To be specific, peer age negatively affects the test scores of male students in these subjects, while the effects for female students, though also negative, are not statistically significant.

Figure 4A exhibits the effects on self-expectations and confidence for male and female students separately. The results reveal no significant gender differences in students' self-expectations regarding educational attainment, career choices, or living locations in the future. Similarly, the effects on self-confidence do not vary by gender. In Figure 4B that shows treatment heterogeneity in health-related outcomes, we only document gender-specific differences in mental health: while there is no significant effect on males' mental health, an increase in peer age considerably improves the mental health of female students. Finally, we investigate heterogeneous effects by gender on students' behaviors and social development. The results presented in Figure 4C suggest differential effects of peer age on disruptive behaviors. To be specific, male students are more likely to engage in problematic behaviors, whereas the effects among females are not statistically significant.

4.3. Mechanisms

In this section, we examine potential mechanisms underlying the observed effects of peer age on student cognitive and non-cognitive outcomes discussed earlier in the paper. Taking advantage of the unique CEPS data across various dimensions, we explore these mechanisms from the perspectives of students, parents, teachers, and the school. Specifically, we examine five aspects: students' effort and persistence in study, the quality of their friends, family investments in education, teacher inputs, and the social environment at school. Our analyses benefit from the longitudinal nature of the data, with all mechanisms examined in this section derived from the baseline wave of the CEPS survey. All regressions use the most inclusive model that controls for the full set of covariates.

4.3.1. Student Effort and Persistence in Study

Students' own effort and persistence in study are critical to their success at school (e.g., Borghans et al., 2008; De Fraja, Oliveira, and Zanchi, 2010; Golsteyn, Non, and Zölitz, 2021). If being exposed to older or younger peers affects the commitment and perseverance students demonstrate in their academic pursuits, peer age could ultimately impact students' academic achievement and performance. To delve into this possible explanation, we construct two separate sets of variables from the CEPS data to measure student effort and persistence, respectively.

The first set of variables measures students' effort in study. Specifically, we calculate the average daily hours devoted to academic and recreational activities. Academic activities include completing homework assigned by teachers, parents, or after-school tutoring classes. Recreational activities encompass watching TV, surfing the Internet, or playing computer games. The second set of variables assesses students' persistence in study. In the survey, students rated their agreement with three statements indicating their academic dedication on a 4-point scale from 1 ("strongly disagree") to 4 ("strongly agree"). These statements gauge students' determination to attend school despite illness, commitment to completing disliked homework, and willingness to exert significant effort on time-consuming assignments. Based on their responses, we construct a dummy variable for each statement that takes a value of

one if a student answers "*agree*" or "*strongly agree*", and zero otherwise.

We re-estimate equation (2) using these two sets of outcomes and report the results in Panels A and B of Table 6, respectively. In Panel A, all estimated coefficients are statistically insignificant and of small magnitude, suggesting that peer age does not affect the time students allocate to study or entertainment. Conversely, Panel B shows significant and negative effects on students' persistence in study. The findings indicate that as peer age increases, students' persistence in completing homework assignments decreases. To account for potential correlations across the three survey questions related to study persistence, we use the improved Bonferroni correction procedure and provide adjusted p-values (shown in brackets below the standard errors) obtained from the multiple hypothesis testing (Newson, 2010; Simes, 1986).[19] Our results remain robust after this adjustment. In summary, the findings provide supportive evidence that peer age could influence student outcomes by affecting the level of persistence students demonstrate in their studies.

4.3.2. Qualities of Students' Friends

Exposure to peers from various age groups could potentially influence students' outcomes by shaping their social circles. For example, if a student chooses to align with peers who display disciplinary issues due to the influence of classmates, it could adversely impact the student's performance. Fortunately, the CEPS dataset offers insights into the attributes of students' best friends, enabling us to delve deeper into this potential mechanism.

Specifically, the CEPS surveyed students to identify their closest friends and assess these friends' academic and behavioral attributes. In terms of academic characteristics, students were asked about the number of best friends who perform well in study, demonstrate diligence in study, and aspire to attend college in the future. Regarding behavioral traits, students were asked to report on the number of best friends involved in disruptive behaviors, including skipping classes or playing truant, violating school regulations, fighting, smoking or drinking alcohol, and frequently visiting internet cafes or game arcades. Responses were categorized into "none of them", "one or two of them", and "most of them". For each trait,

[19] See Erten and Keskin (2018), Kottelenberg and Lehrer (2017), and Yu and Mocan (2019) for examples of applications of the method.

we construct a dummy variable that takes a value of one if students state that *most* of their best friends exhibit that specific characteristic, and zero otherwise. Therefore, these dummy variables act as indicators of the presence of positive or negative qualities among students' closest friends.

Using these eight dummy variables as the outcomes, we investigate the relationship between peer age and the likelihood of students having friends with desirable or undesirable traits. We present the results in Table 7. Columns 1–3 reveal a notable negative effect of peer age on the probability of students associating with friends who exhibit positive attributes such as academic excellence, dedication to studies, and aspirations for college education. The estimated effects are substantial, indicating significant decreases of 6.6 to 7.7 percentage points (or 9% to 15% declines compared to the means) resulting from a one-standard deviation increase in the peer age. These findings suggest that as peer age increases, there is a discernible reduction in the number of friends who actively pursue academic success. In contrast, we find no statistically significant estimates in Columns 4–8. This indicates that peer age does not influence the likelihood of students forming friendships with those exhibiting problematic behaviors.

4.3.3. Family Investment

The effect of peer age on student outcomes could be explained through the lens of family investment. It is plausible that parents adjust their level of inputs based on the perceived needs and challenges presented by their child's classroom environment. For instance, if a student is in a classroom with older peers, parents might view these peers as more mature or advanced academically and socially. This could prompt parents to increase their investment in their child's education, such as arranging additional tutoring, dedicating more time to homework, or encouraging extracurricular activities, to help their child keep pace with older classmates. Additionally, the age composition of a student's peer group could shape how parents manage their child's social interactions and emotional development. Parents may, for instance, encourage socialization with older peers to foster maturity or provide extra emotional support if the child struggles to keep up. Conversely, with younger peers, parents might focus on fostering leadership skills and reinforcing self-confidence. These could

potentially affect the child's non-cognitive outcomes.

The CEPS data provide insights into these dynamics by capturing various aspects of family investment in a child's education and social development. We create binary variables to indicate whether a child participates in after-school tutoring, whether parents check homework, and whether parents assist with homework. Moreover, we include a variable that reflects the average daily hours parents spend on their child such as caregiving, homework assistance, and recreational activities. In addition, parents reported how frequently they discuss certain topics with their child, including things happened at school, relationships with friends and teachers, the child's feelings, and any concerns or worries. Based on these responses, we construct five dummy variables, coded as one if parents reported *sometimes* or *often* engaging in these conversations, and zero if they reported never doing so.

The results presented in Table 8 show no statistically significant effects of peer age on parental investment, with the estimates being small in magnitude. These findings suggest that peer age is unlikely to play a meaningful role in influencing student outcomes through parental involvement in their child's educational, social, or emotional development in our context.

4.3.4. Teacher Inputs

Awareness of the age distribution among students in class can influence how teachers engage with them. Students' perceptions of how teachers interact and behave towards them play a critical role in shaping both their cognitive and non-cognitive outcomes. The CEPS contains a series of survey questions that gauge these perceptions regarding how students were treated by subject teachers and homeroom teachers. By leveraging this valuable information, we provide direct evidence that sheds lights on potential mechanisms of teacher inputs.

In the CEPS, students were surveyed about their views on whether their math, Chinese, and English teachers often ask them to answer questions in class or offer praise. Additionally, students reflected on their homeroom teacher's tendency to praise or criticize them. Responses were measured on a 4-point scale ranging from 1 ("strongly disagree") to 4 ("strongly agree"). We construct binary indicators for each survey question separately by

assigning a value of one if the student *agrees* or *strongly agrees* with the statement, and zero otherwise.

We re-estimate equation (2) with these indicators as outcomes, and present the results in Table 9. Our findings indicate that there are no statistically significant impacts of peer age on teachers' behaviors or attitudes. Most estimated coefficients are small in magnitude. In summary, we find no evidence to suggest that peer age might be a significant factor in affecting students' outcomes through teacher inputs.

4.3.5. Social Environment at School

Our analysis continues by examining variables associated with the social atmosphere within the school setting. Extensive literature highlights the strong relationship between both physical and social dimensions of the school environment and students' academic performance and long-term outcomes (e.g., Cabral et al., 2021; Kwong and Davis, 2015; Webster and Fisher, 2003). Students' perceptions of this environment are particularly important, as their perspectives are the ultimate and direct determinants of these relationships. Understanding how students view the social dynamics of their schools can provide valuable insights into their cognitive and non-cognitive outcomes.

The CEPS features a series of survey questions designed to evaluate students' perceptions of their school environment. Specifically, students were asked to indicate their level of agreement with statements such as: (1) Most classmates are very friendly to me; (2) I can get along with people easily; (3) The atmosphere in my class is good; (4) I often participate in class activities; (5) I feel close to people at school; (6) I feel bored at school. Responses were collected on a 4-point scale ranging from 1 ("strongly disagree") to 4 ("strongly agree"). We then construct six dummy variables, assigning a value of one if the student *agrees* or *strongly agrees* with the respective statements, and zero otherwise.

Employing these variables as outcomes, we re-estimate equation (2) and present the results in Table 10. The findings reveal a negative and statistically significant impact of peer age on social environment, particularly within the classroom (see Columns 1–4). Given the correlation and similarity among these survey questions, we employ the multiple hypothesis testing and present adjusted p-values in brackets. Our main conclusions remain unchanged

after the adjustment.

4.3.6. Summary

Overall, our results indicate that peer age primarily influences student outcomes through three distinct channels. First, as peer age increases, students' commitment to studying diminishes, as evidenced by a decreased likelihood of completing challenging or disliked homework assignments. Second, the rise in peer age impacts the qualities of students' friends by reducing the number of closest friends who actively and ambitiously pursue academic success. Third, the increase in peer age has a negative effect on students' perception of their social environment at school. However, our analysis does not find evidence that the age composition of students affects family investment, or teachers' behaviors or attitudes towards students.

5. Conclusion

Peer effects are crucial because they profoundly influence individual behavior, decision-making, and overall development. Our paper examines the effects of peer age on both cognitive and non-cognitive outcomes among students who were randomly assigned to classrooms at the start of middle school. The random assignment enables us to compare students of the same middle school entry age who were exposed to different but exogenously determined peer age compositions at the school-grade level. This variation in peer age provides a solid foundation for identifying the causal relationships in our context.

We find that an increase in the age of peers leads to declines in students' test scores and cognitive skills. Furthermore, an increase in peer age negatively influences non-cognitive outcomes, such as self-expectations, confidence, participation in virtuous behaviors, and social development. Our heterogeneity analysis suggests that students older than their peers are more susceptible to these negative effects, especially regarding overall health, mental well-being, and social behaviors, compared to students younger than their peers. The gender-specific analysis reveals that male students experience more pronounced declines in Chinese and English test scores, while female students tend to show improved mental health

with increased peer age. Additionally, males are more likely to exhibit disruptive behaviors as peer age rises. We also explore the mechanisms driving these effects. We find that students' study persistence, friend selection, and the overall school climate play important roles in shaping the impact of peer age on student outcomes.

Our findings underscore the importance of peer age composition as a key factor influencing both cognitive and non-cognitive development during adolescence. These results carry significant implications for educational policies. Schools and policymakers should consider peer age dynamics when designing classroom assignments and interventions. For instance, strategies aimed at balancing peer age composition may help mitigate the negative impacts on academic performance and social development. Additionally, targeted support for students, especially older students and males who are more vulnerable to negative peer age effects, could promote better outcomes. By integrating peer age considerations into school policies, educators can create more equitable learning environments that foster academic success and emotional well-being for all students.

References

Ahn, Tom and Justin G Trogdon. 2017. "Peer delinquency and student achievement in middle school." *Labour Economics* 44:192–217.

Antecol, Heather, Ozkan Eren, and Serkan Ozbeklik. 2016. "Peer effects in disadvantaged primary schools: Evidence from a randomized experiment." *Journal of Human Resources* 51 (1):95–132.

Balestra, Simone, Beatrix Eugster, and Helge Liebert. 2022. "Peers with special needs: Effects and policies." *The Review of Economics and Statistics* 104 (3):602–618.

Barua, Rashmi and Kevin Lang. 2016. "School entry, educational attainment, and quarter of birth: A cautionary tale of a local average treatment effect." *Journal of Human Capital* 10 (3):347–376.

Bedard, Kelly and Elizabeth Dhuey. 2006. "The persistence of early childhood maturity: International evidence of long-run age effects." *The Quarterly Journal of Economics* 121 (4):1437–1472.

Berggren, Niclas, Henrik Jordahl, and Panu Poutvaara. 2010. "The looks of a winner: Beauty and electoral success." *Journal of Public Economics* 94 (1-2):8–15.

Black, Sandra E, Paul J Devereux, and Kjell G Salvanes. 2011. "Too young to leave the nest? The effects of school starting age." *The Review of Economics and Statistics* 93 (2):455–467.

———. 2013. "Under pressure? The effect of peers on outcomes of young adults." *Journal of Labor Economics* 31 (1):119–153.

Borghans, Lex, Angela Lee Duckworth, James J Heckman, and Bas Ter Weel. 2008. "The economics and psychology of personality traits." *Journal of Human Resources* 43 (4):972–1059.

Brenøe, Anne Ardila and Ulf Zölitz. 2020. "Exposure to more female peers widens the gender gap in STEM participation." *Journal of Labor Economics* 38 (4):1009–1054.

Burke, Mary A and Tim R Sass. 2013. "Classroom peer effects and student achievement." *Journal of Labor Economics* 31 (1):51–82.

Bursztyn, Leonardo, Florian Ederer, Bruno Ferman, and Noam Yuchtman. 2014. "Understanding mechanisms underlying peer effects: Evidence from a field experiment on financial decisions." *Econometrica* 82 (4):1273–1301.

Cabral, Marika, Bokyung Kim, Maya Rossin-Slater, Molly Schnell, and Hannes Schwandt. 2021. "Trauma at school: The impacts of shootings on students' human capital and economic outcomes." *National Bureau of Economic Research* .

Carlana, Michela, Eliana La Ferrara, and Paolo Pinotti. 2022. "Goals and gaps: Educational careers of immigrant children." *Econometrica* 90 (1):1–29.

Carrell, Scott E, Richard L Fullerton, and James E West. 2009. "Does your cohort matter? Measuring peer effects in college achievement." *Journal of Labor Economics* 27 (3):439–464.

Carrell, Scott E, Mark Hoekstra, and Elira Kuka. 2018. "The long-run effects of disruptive peers." *American Economic Review* 108 (11):3377–3415.

Carrell, Scott E and Mark L Hoekstra. 2010. "Externalities in the classroom: How children exposed to domestic violence affect everyone's kids." *American Economic Journal: Applied Economics* 2 (1):211–228.

Carrell, Scott E, Frederick V Malmstrom, and James E West. 2008. "Peer effects in academic cheating." *Journal of Human Resources* 43 (1):173–207.

Cascio, Elizabeth U and Diane Whitmore Schanzenbach. 2016. "First in the class? Age and the education production function." *Education Finance and Policy* 11 (3):225–250.

Cipriani, Giam Pietro and Angelo Zago. 2011. "Productivity or discrimination? Beauty and the exams." *Oxford Bulletin of Economics and Statistics* 73 (3):428–447.

Cook, Philip J and Songman Kang. 2016. "Birthdays, schooling, and crime: Regression-discontinuity analysis of school performance, delinquency, dropout, and crime initiation." *American Economic Journal: Applied Economics* 8 (1):33–57.

Costas-Fernández, Julián, Greta Morando, and Angus Holford. 2023. "The effect of foreign students in higher education on native students' outcomes." *European Economic Review* 160:104595.

Damm, Anna Piil and Cédric Gorinas. 2020. "Prison as a criminal school: Peer effects and criminal learning behind bars." *Journal of Law and Economics* 63 (1):149–180.

Datar, Ashlesha. 2006. "Does delaying kindergarten entrance give children a head start?" *Economics of Education Review* 25 (1):43–62.

De Fraja, Gianni, Tania Oliveira, and Luisa Zanchi. 2010. "Must try harder: Evaluating the role of effort in educational attainment." *The Review of Economics and Statistics* 92 (3):577–597.

Dhuey, Elizabeth, David Figlio, Krzysztof Karbownik, and Jeffrey Roth. 2019. "School starting age and cognitive development." *Journal of Policy Analysis and Management* 38 (3):538–578.

Dhuey, Elizabeth and Stephen Lipscomb. 2008. "What makes a leader? Relative age and high school leadership." *Economics of Education Review* 27 (2):173–183.

Dobkin, Carlos and Fernando Ferreira. 2010. "Do school entry laws affect educational attainment and labor market outcomes?" *Economics of education review* 29 (1):40–54.

Duarte, Jefferson, Stephan Siegel, and Lance Young. 2012. "Trust and credit: The role of appearance in peer-to-peer lending." *The Review of Financial Studies* 25 (8):2455–2484.

Duflo, Esther, Pascaline Dupas, and Michael Kremer. 2011. "Peer effects, teacher incentives, and the impact of tracking: Evidence from a randomized evaluation in Kenya." *American Economic Review* 101 (5):1739–1774.

Elder, Todd E and Darren H Lubotsky. 2009. "Kindergarten entrance age and children's achievement: Impacts of state policies, family background, and peers." *Journal of Human Resources* 44 (3):641–683.

Elsner, Benjamin and Ingo E Isphording. 2017. "A big fish in a small pond: Ability rank and human capital investment." *Journal of Labor Economics* 35 (3):787–828.

Erten, Bilge and Pinar Keskin. 2018. "For better or for worse?: Education and the prevalence of domestic violence in Turkey." *American Economic Journal: Applied Economics* 10 (1):64–105.

Fredriksson, Peter and Björn Öckert. 2014. "Life-cycle effects of age at school start." *The Economic Journal* 124 (579):977–1004.

Fumarco, Luca and Stijn Baert. 2019. "Relative age effect on European adolescents' social network." *Journal of Economic Behavior & Organization* 168:318–337.

Golsteyn, Bart HH, Arjan Non, and Ulf Zölitz. 2021. "The impact of peer personality on academic achievement." *Journal of Political Economy* 129 (4):1052–1099.

Guo, Chuanyi, Xuening Wang, and Chen Meng. 2023. "Does the early bird catch the worm? Evidence and interpretation on the long-term impact of school entry age in China." *China Economic Review* 77:101900.

Guryan, Jonathan, Kory Kroft, and Matthew J. Notowidigdo. 2009. "Peer effects in the workplace: Evidence from random groupings in professional golf tournaments." *American Economic Journal: Applied Economics* 1 (4):34–68.

Hanushek, Eric A. 1979. "Conceptual and empirical issues in the estimation of educational production functions." *Journal of Human Resources* 14 (3):351–388.

Heckman, James J, Bridget Galaty, and Haihan Tian. 2023. "The economic approach to personality, character and virtue." *National Bureau of Economic Research* .

Kottelenberg, Michael J and Steven F Lehrer. 2017. "Targeted or universal coverage? Assessing heterogeneity in the effects of universal child care." *Journal of Labor Economics* 35 (3):609–653.

Kwong, Darren and Jonathan Ryan Davis. 2015. "School climate for academic success: A multilevel analysis of school climate and student outcomes." *Journal of Research in Education* 25 (2):68–81.

Lavy, Victor, Olmo Silva, and Felix Weinhardt. 2012. "The good, the bad, and the average: Evidence on ability peer effects in schools." *Journal of Labor Economics* 30 (2):367–414.

Manski, Charles F. 1993. "Identification of endogenous social effects: The reflection problem." *The Review of Economic Studies* 60 (3):531–542.

McEwan, Patrick J and Joseph S Shapiro. 2008. "The benefits of delayed primary school enrollment: Discontinuity estimates using exact birth dates." *Journal of Human Resources* 43 (1):1–29.

Michelman, Valerie, Joseph Price, and Seth D Zimmerman. 2022. "Old boys' clubs and upward mobility among the educational elite." *The Quarterly Journal of Economics* 137 (2):845–909.

Mobius, Markus M and Tanya S Rosenblat. 2006. "Why beauty matters." *American Economic Review* 96 (1):222–235.

Mocan, Naci H and Eric Osborne-Christenson. 2022. "In-group favoritism and peer effects in wrongful acquittals: NBA referees as judges." *National Bureau of Economic Research* .

Mühlenweg, Andrea M and Patrick A Puhani. 2010. "The evolution of the school-entry age effect in a school tracking system." *Journal of Human Resources* 45 (2):407–438.

Murphy, Richard and Felix Weinhardt. 2020. "Top of the class: The importance of ordinal rank." *The Review of Economic Studies* 87 (6):2777–2826.

Newson, Roger B. 2010. "Frequentist q-values for multiple-test procedures." *The Stata Journal* 10 (4):568–584.

Olivetti, Claudia, Eleonora Patacchini, and Yves Zenou. 2020. "Mothers, peers, and gender-role identity." *Journal of the European Economic Association* 18 (1):266–301.

Peña, Pablo A. 2017. "Creating winners and losers: Date of birth, relative age in school, and outcomes in childhood and adulthood." *Economics of Education Review* 56:152–176.

Persico, Nicola, Andrew Postlewaite, and Dan Silverman. 2004. "The effect of adolescent experience on labor market outcomes: The case of height." *Journal of Political Economy* 112 (5):1019–1053.

Shigeoka, Hitoshi. 2015. "School entry cutoff date and the timing of births." *National Bureau of Economic Research* .

Shure, Nikki. 2021. "Non-cognitive peer effects in secondary education." *Labour Economics* 73:102074.

Simes, John. 1986. "An improved Bonferroni procedure for multiple tests of significance." *Biometrika* 73 (3):751–754.

Webster, Beverley J and Darrell L Fisher. 2003. "School-level environment and student outcomes in mathematics." *Learning Environments Research* 6:309–326.

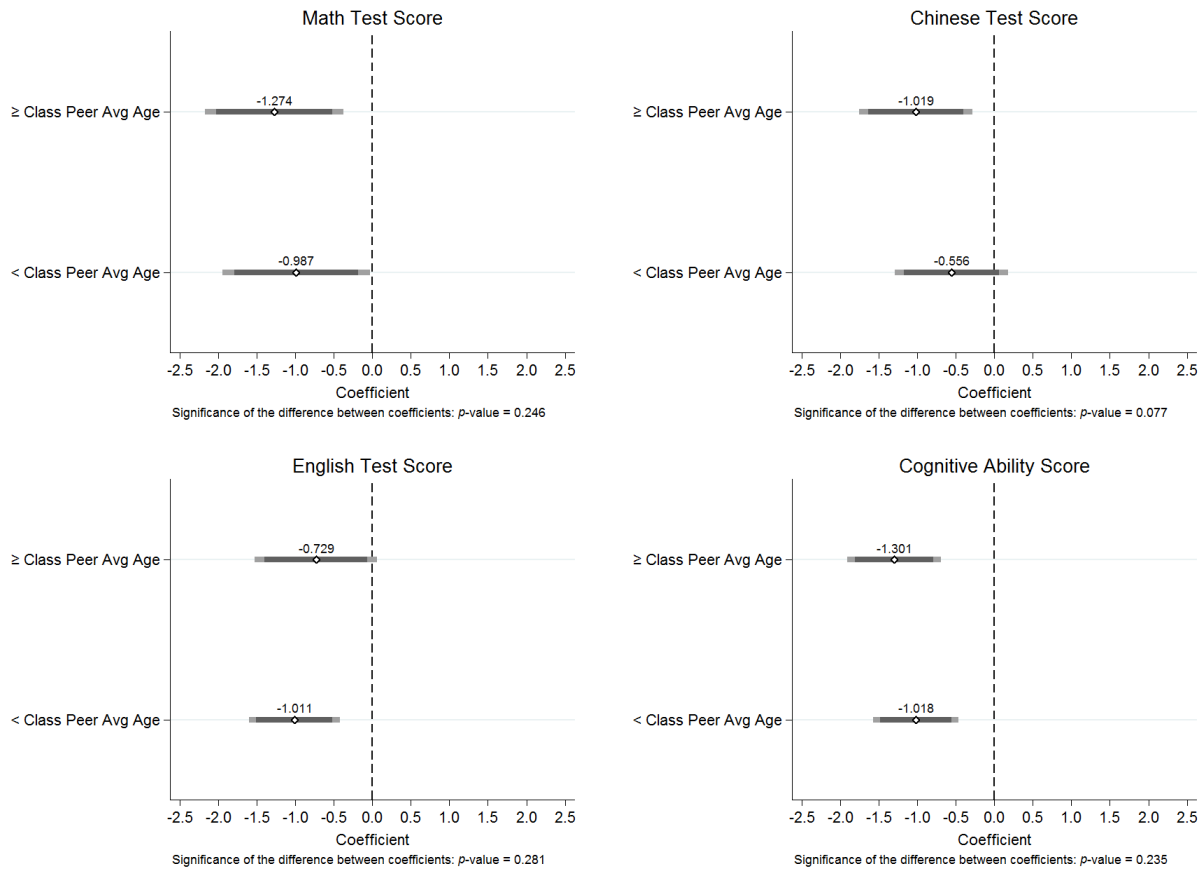
Xu, Di, Qing Zhang, and Xuehan Zhou. 2022. "The impact of low-ability peers on cognitive and noncognitive outcomes: Random assignment evidence on the effects and operating channels." *Journal of Human Resources* 57 (2):555–596.

Yu, Han. 2020. "Am I the big fish? The effect of ordinal rank on student academic performance in middle school." *Journal of Economic Behavior & Organization* 176:18–41.

Yu, Han and Naci Mocan. 2019. "The impact of high school curriculum on confidence, academic success, and mental and physical well-being of university students." *Journal of Labor Research* 40:428–462.

Zimmerman, David J. 2003. "Peer effects in academic outcomes: Evidence from a natural experiment." *The Review of Economics and Statistics* 85 (1):9–23.

Figure 1: Heterogeneous Effects of Peer Age on Cognitive Outcomes - By Student Relative Age



Notes: Each figure displays the estimated effects of peer age on a specific cognitive outcome by student relative age. We obtain these coefficients by re-estimating equation (2) using our most extended regression model (as in Table 4, Column 4), separately for students who are older than or the same age as their classroom peers, and for those who are younger. At the bottom of each figure, we report the p-values of the F-test for the difference between each pair of estimated coefficients. Darker bars represent the 90% confidence interval, while lighter bars indicate the 95% confidence interval.

Figure 2A: Heterogeneous Effects of Peer Age on Non-Cognitive Outcomes - By Student Relative Age

Panel A: Self-Expectations and Confidence

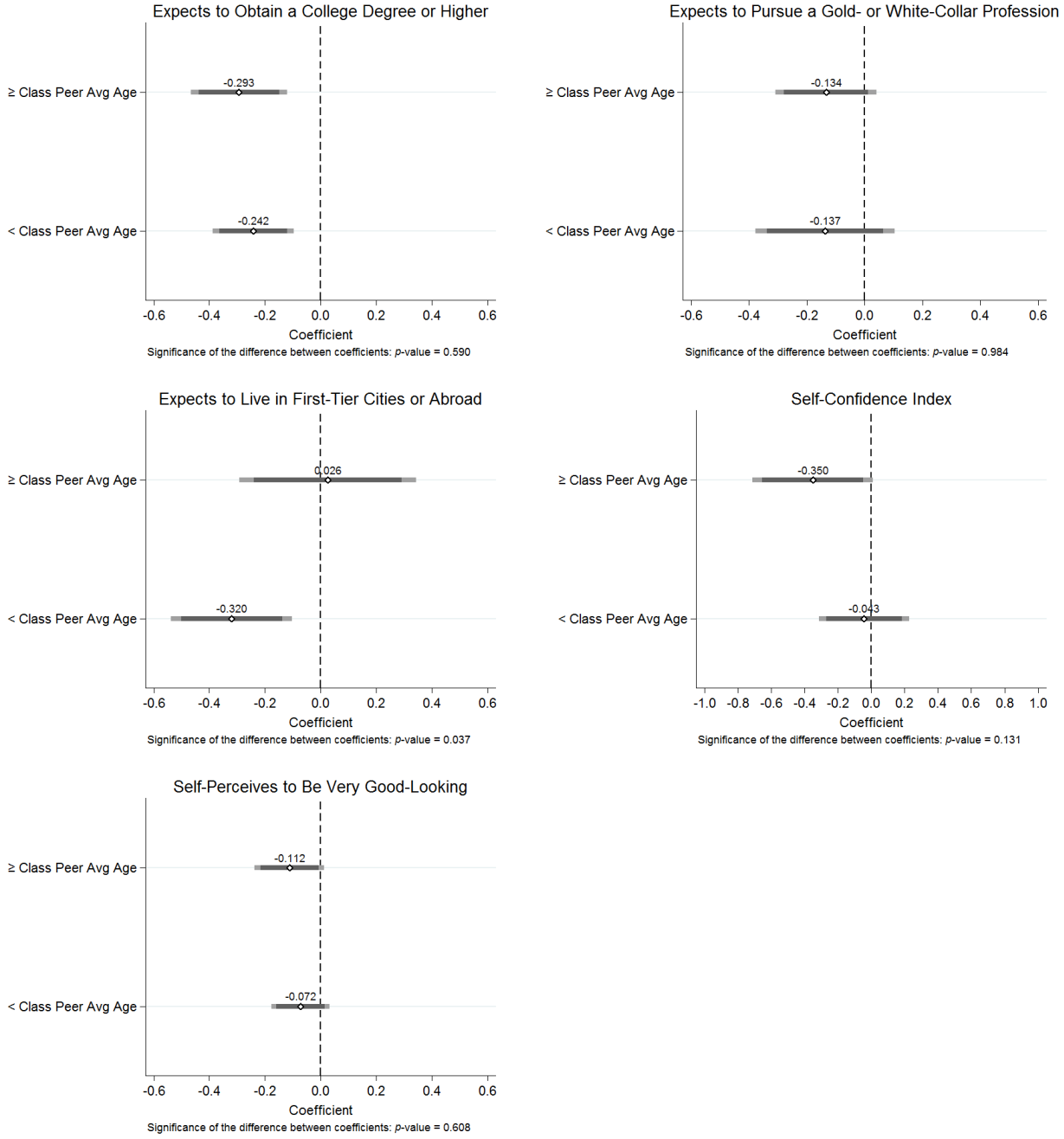
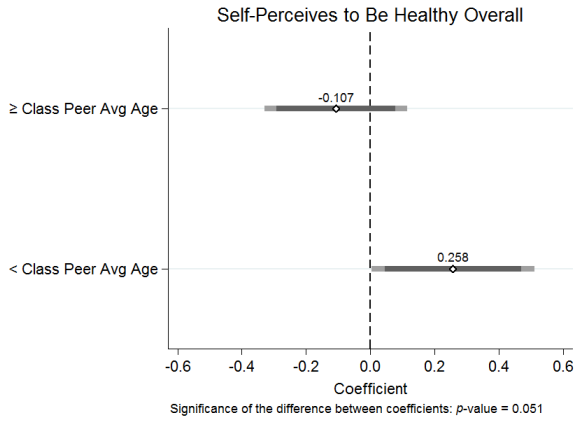
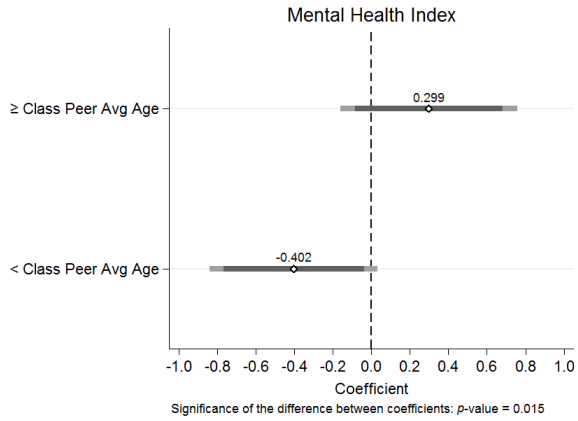
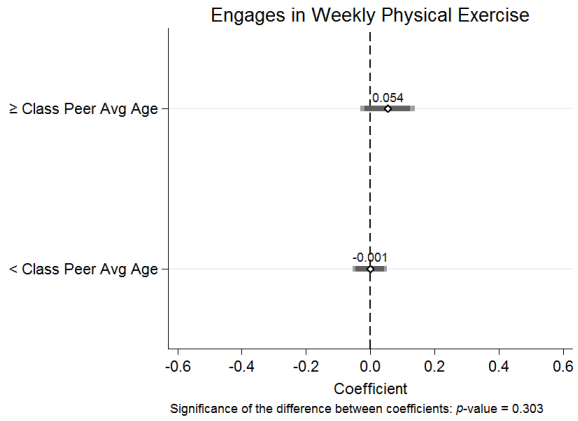


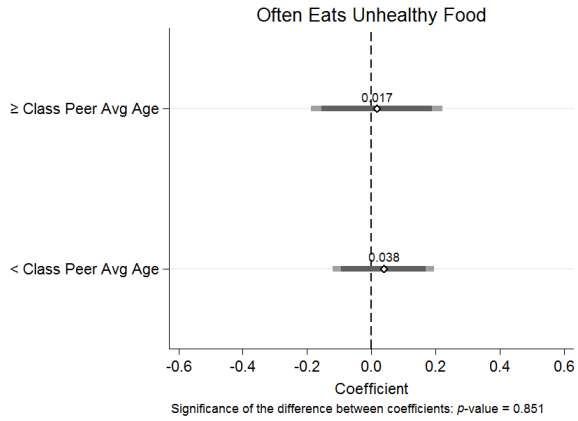
Figure 2B: Heterogeneous Effects of Peer Age on Non-Cognitive Outcomes - By Student Relative Age (Continued)

Panel B: Health









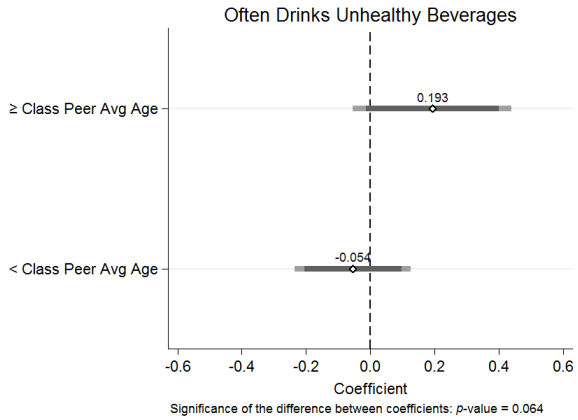
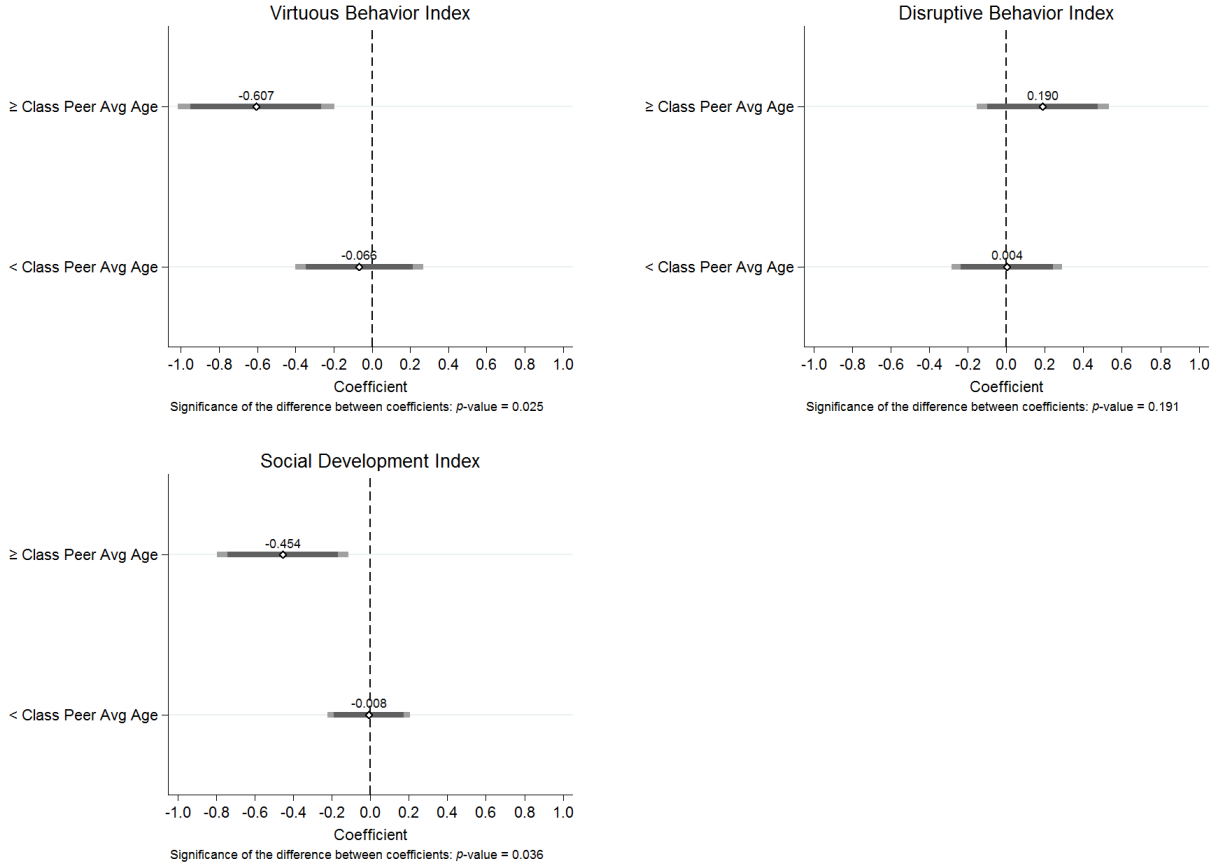


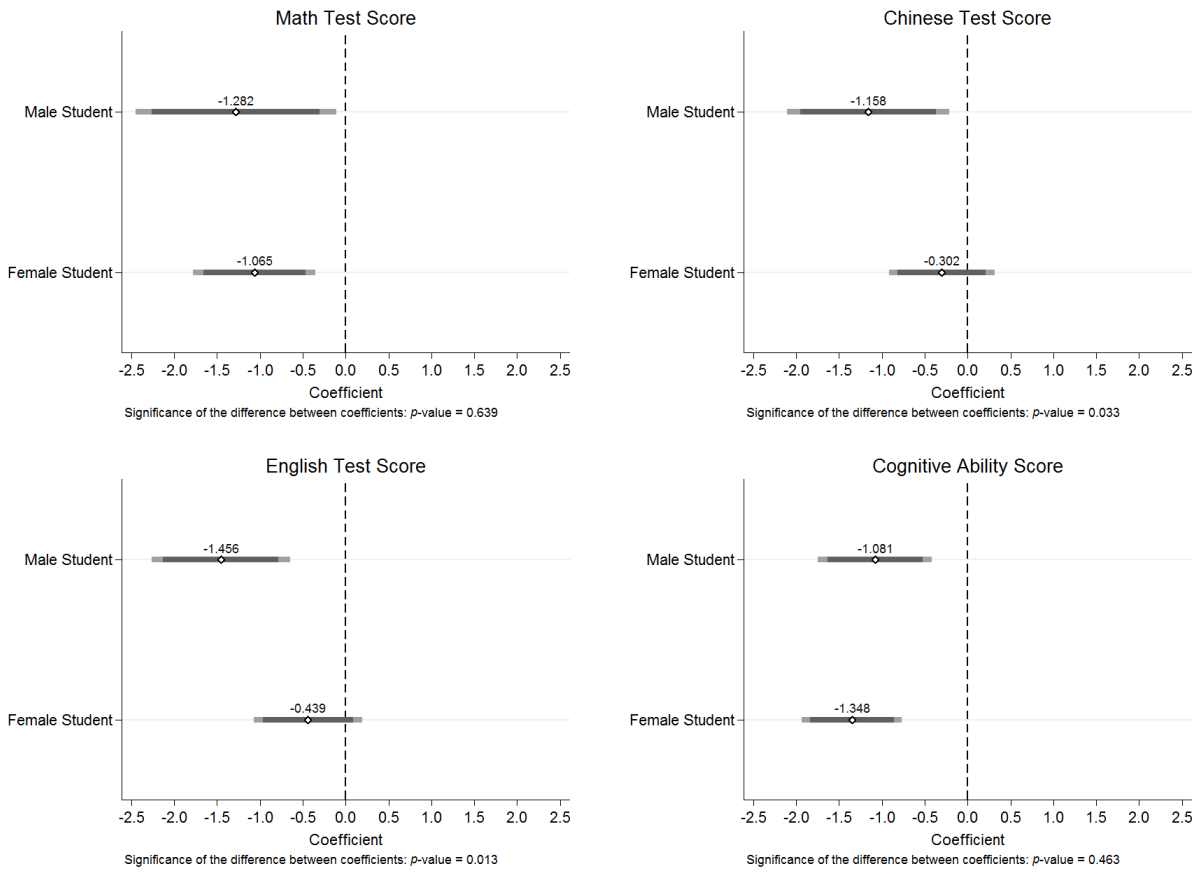
Figure 2C: Heterogeneous Effects of Peer Age on Non-Cognitive Outcomes - By Student Relative Age (Continued)

Panel C: Behaviors and Social Development



Notes: Each figure displays the estimated effects of peer age on a specific non-cognitive outcome by student relative age. We obtain these coefficients by re-estimating equation (2) using our most extended regression model (as in Table 4, Column 4), separately for students who are older than or the same age as their classroom peers, and for those who are younger. At the bottom of each figure, we report the p-values of the F-test for the difference between each pair of estimated coefficients. Darker bars represent the 90% confidence interval, while lighter bars indicate the 95% confidence interval.

Figure 3: Heterogeneous Effects of Peer Age on Cognitive Outcomes - By Student Gender



Notes: Each figure displays the estimated effects of peer age on a specific cognitive outcome by student gender. We obtain these coefficients by re-estimating equation (2) using our most extended regression model (as in Table 4, Column 4), separately for male and female students. At the bottom of each figure, we report the p-values of the F-test for the difference between each pair of estimated coefficients. Darker bars represent the 90% confidence interval, while lighter bars indicate the 95% confidence interval.

Figure 4A: Heterogeneous Effects of Peer Age on Non-Cognitive Outcomes - By Student Gender

Panel A: Self-Expectations and Confidence

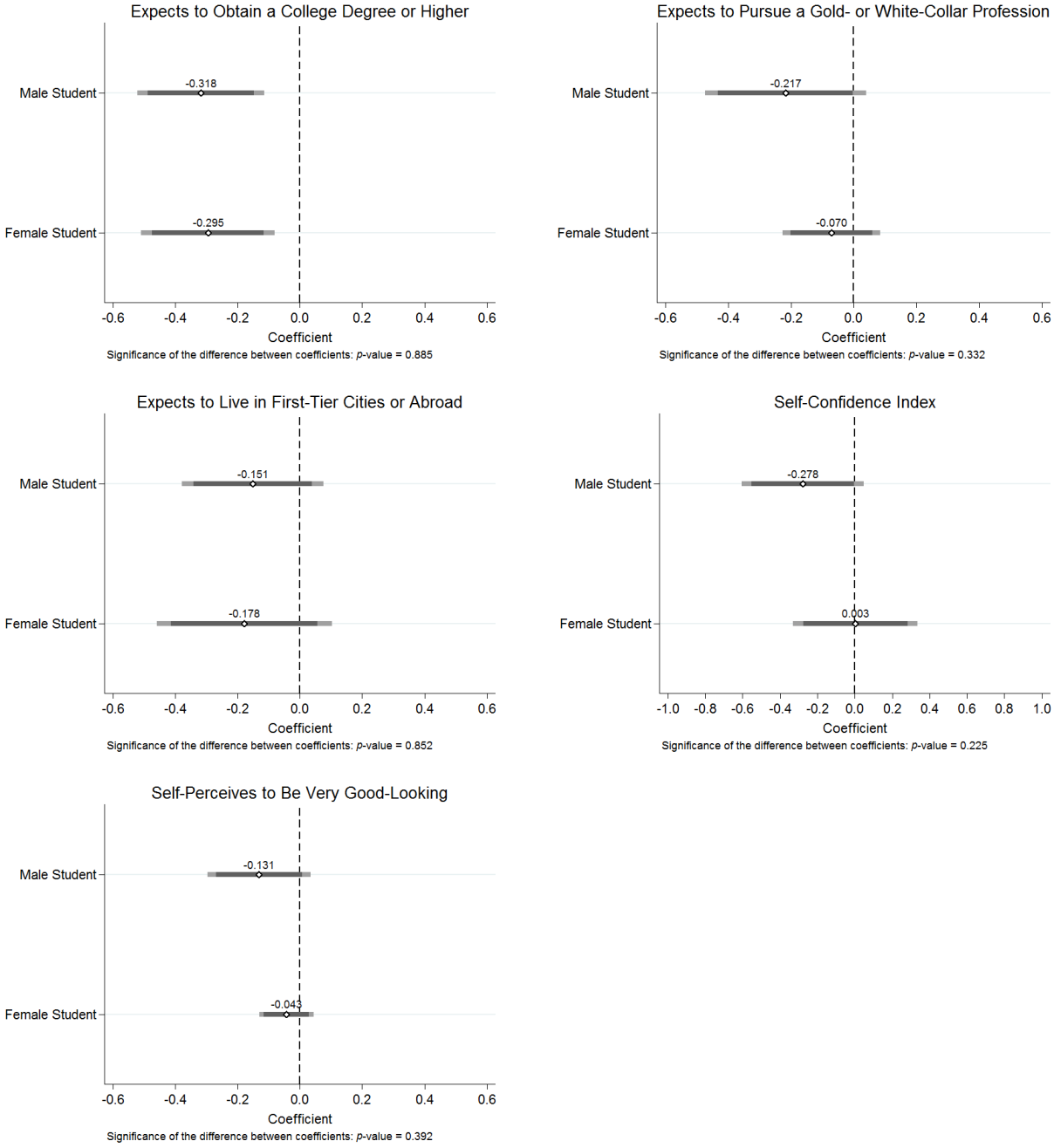
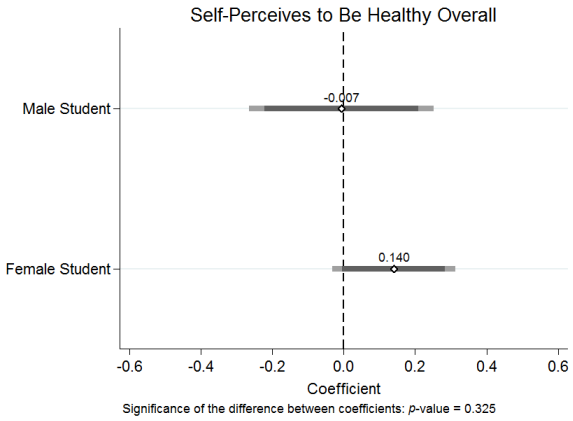
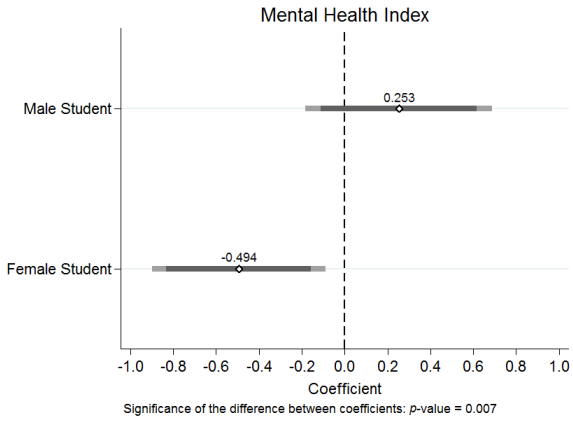
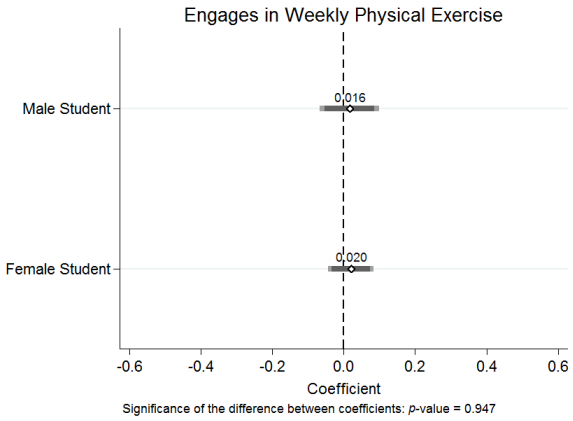


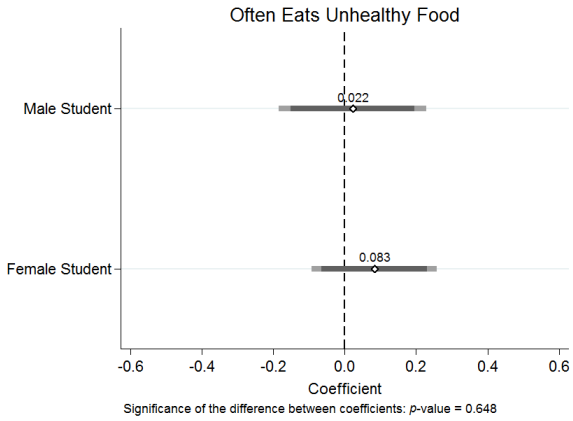
Figure 4B: Heterogeneous Effects of Peer Age on Non-Cognitive Outcomes - By Student Gender (Continued)

Panel B: Health









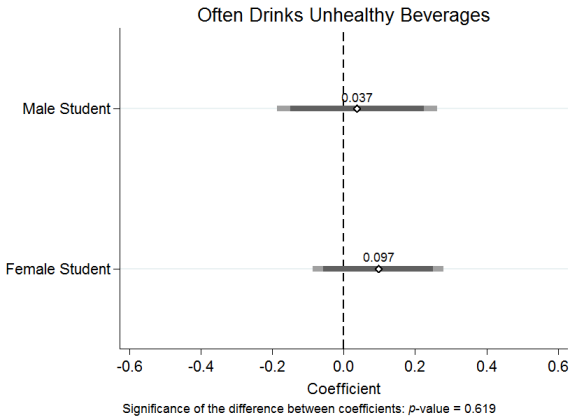
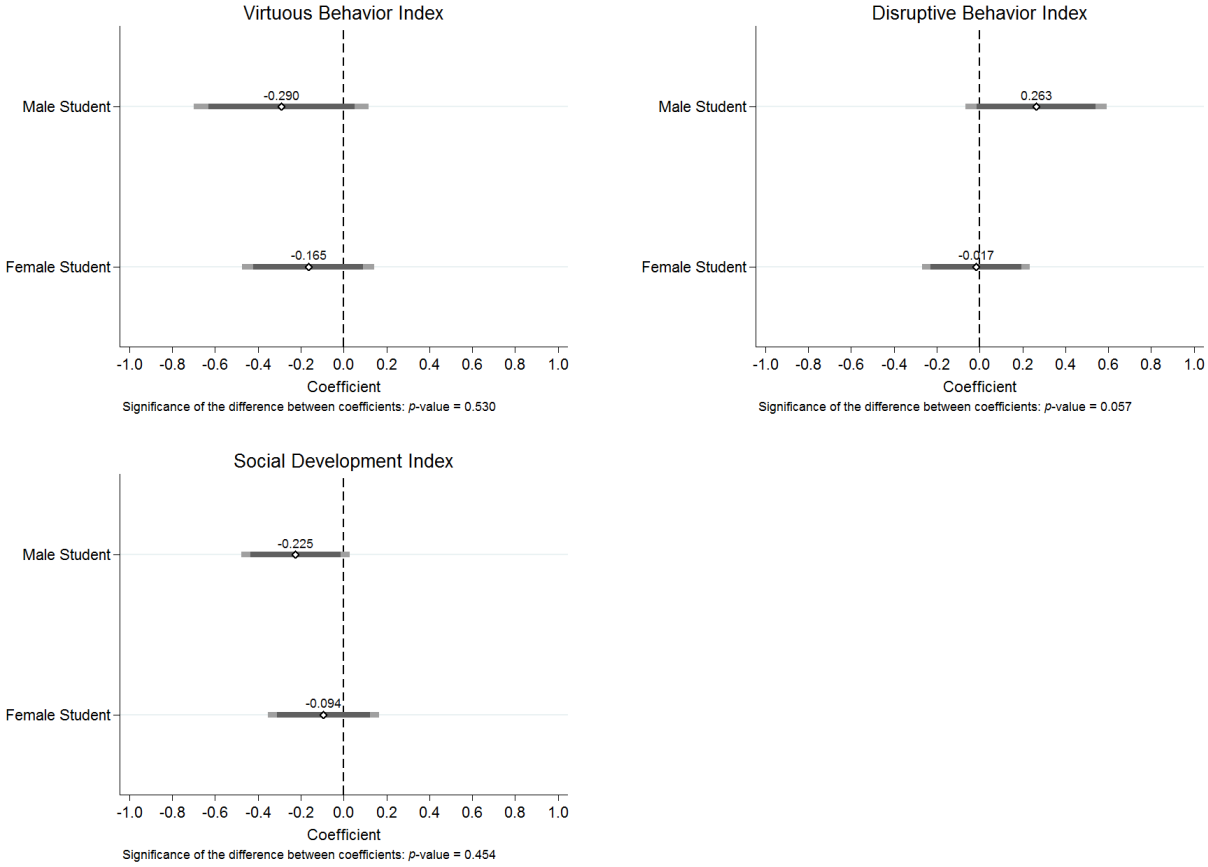


Figure 4C: Heterogeneous Effects of Peer Age on Non-Cognitive Outcomes - By Student Gender (Continued)

Panel C: Behaviors and Social Development



Notes: Each figure displays the estimated effects of peer age on a specific non-cognitive outcome by student gender. We obtain these coefficients by re-estimating equation (2) using our most extended regression model (as in Table 4, Column 4), separately for male and female students. At the bottom of each figure, we report the p-values of the F-test for the difference between each pair of estimated coefficients. Darker bars represent the 90% confidence interval, while lighter bars indicate the 95% confidence interval.

Table 1: Summary Statistics

	Mean (1)	Std. Dev. (2)	Obs. (3)
Panel A: Cognitive Outcomes			
Math test core	77.787	30.787	5087
Chinese test score	82.098	19.228	5087
English test score	75.723	29.461	5087
Cognitive ability score	0.404	0.795	5136
Panel B: Non-cognitive Outcomes			
Self-Expectations and Confidence			
Expects to obtain a college degree or higher (yes = 1, 0 otherwise)	0.867	0.340	4937
Expects to pursue a gold- or white-collar profession (yes = 1, 0 otherwise)	0.763	0.425	4863
Expects to live in first-tier cities or abroad (yes = 1, 0 otherwise)	0.657	0.475	4512
Self-confidence index (range: 1–4; higher values indicate greater self-confidence)	3.040	0.675	5146
Self-perceives to be very good-looking (yes = 1, 0 otherwise)	0.057	0.232	5131
Health			
Self-perceives to be healthy overall (yes = 1, 0 otherwise)	0.656	0.475	5133
Mental health index (range: 1–5; higher values indicate worse mental health)	2.161	0.826	5061
Engages in weekly physical exercise (yes = 1, 0 otherwise)	0.973	0.163	5076
Often eats unhealthy food (yes = 1, 0 otherwise)	0.135	0.342	5138
Often drinks unhealthy beverages (yes = 1, 0 otherwise)	0.214	0.410	5118
Behaviors and Social Development			
Virtuous behavior index (range: 1–5; higher values indicate more virtuous behaviors)	3.836	0.744	5150
Disruptive behavior index (range: 1–5; higher values indicate more disruptive behaviors)	1.516	0.462	5086
Social development index (range: 1–4; higher values indicate greater social development)	2.981	0.500	5061
Panel C: Regressor of Interest:			
Peer school entry age	12.717	0.327	5177
Panel D: Predetermined Student Characteristics:			
Own school entry age	12.699	0.625	5177
Female	0.490	0.500	5177
Minority	0.089	0.285	5177
Rural residence	0.453	0.498	5177
Local residence	0.743	0.437	5177
Only child in family	0.505	0.500	5177
Kindergarten attendance	0.835	0.371	5177
Mother college degree or higher	0.172	0.377	5177
Father college degree or higher	0.201	0.401	5177
Mother blue-collar occupation	0.323	0.468	5177
Father blue-collar occupation	0.349	0.477	5177
High-income family before primary school	0.059	0.236	5177

Notes: The table shows means and standard deviations for the analytical sample. We present the raw values of mid-term exam and cognitive ability test scores. The number of observations for students' cognitive and non-cognitive outcomes varies because these variables have different amounts of missing data.

Table 2: Randomization Test: Does Peer School Entry Age Predict Own Entry Age?

	Student's own age at middle school entry (1)	Student's own age at middle school entry (2)
Average peer school entry age within classroom	-0.099	0.065
	(0.324)	(0.044)
Block fixed effects	✓	✓
Average peer school entry age within block	✗	✓
Observations	5177	5177

Notes: The dependent variable is the student's own age at middle school entry. Standard errors are clustered at the block level and reported in the parentheses. Randomization regressions include block fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3: Randomization Test: Do Teacher and Student Characteristics Predict Average School Entry Age?

	Average student age at middle school entry (1)	Average student age at middle school entry (2)
Teacher Characteristics		
Female homeroom teacher	0.007	-0.011
	(0.034)	(0.049)
Homeroom teacher age	-0.001	-0.008
	(0.005)	(0.008)
Homeroom teacher teaching experience	0.003	0.006
	(0.004)	(0.006)
Homeroom teacher holds a Master's degree	-0.132	-0.083
	(0.115)	(0.130)
Homeroom teacher holds a Bachelor's degree	-0.175**	-0.064
	(0.075)	(0.081)
Homeroom teacher graduated from a normal university	-0.103	-0.039
	(0.084)	(0.082)
Student Characteristics		
Proportion of female students	-0.441	-0.377
	(0.266)	(0.531)
Proportion of minority students	0.702***	-0.132
	(0.122)	(0.848)
Proportion of students with rural residency	0.059	0.154
	(0.171)	(0.221)
Proportion of students with local residency	-0.054	-0.028
	(0.097)	(0.197)
Proportion of students who are the only child in family	-0.213	-0.420
	(0.137)	(0.253)
Proportion of students who ever attended kindergarten	-0.311*	-0.072
	(0.169)	(0.320)
Proportion of fathers holding a college degree or higher	-0.219	0.194
	(0.187)	(0.288)
Proportion of mothers holding a college degree or higher	0.058	-0.447
	(0.217)	(0.340)
Proportion of fathers with a blue-collar occupation	-0.123	-0.109
	(0.174)	(0.318)
Proportion of mothers with a blue-collar occupation	-0.192	0.077
	(0.194)	(0.348)
Proportion of high-income family before primary school	-0.482	0.387
	(0.385)	(0.502)
Class size	-0.002	0.006
	(0.002)	(0.010)
Test for joint significance:		
F-statistics	14.08	0.83
p-value	0.00	0.66
Block fixed effects	✗	✓
Number of classrooms	151	151

Notes: Observations are at the classroom level. Each cell presents the estimated coefficient and standard error for teacher characteristics and student predetermined characteristics aggregated at the classroom level. The dependent variable is average student middle school entry age measured at the classroom level. The independent variables are all of the listed characteristics. Standard errors are clustered at the block level and reported in the parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Effects of Peer Age on Student Cognitive Outcomes

	Coefficient (Standard Error)				
	(1)	(2)	(3)	(4)	Observations
Dependent Variables					
Math test score	-1.286**	-1.233**	-1.110**	-1.096**	5087
	(0.547)	(0.549)	(0.455)	(0.449)	
Chinese test score	-0.924**	-0.847**	-0.765**	-0.772**	5087
	(0.407)	(0.419)	(0.335)	(0.341)	
English test score	-1.342***	-1.252***	-1.038***	-0.927***	5087
	(0.445)	(0.453)	(0.323)	(0.307)	
Cognitive ability score	-1.318***	-1.279***	-1.230***	-1.158***	5136
	(0.318)	(0.318)	(0.257)	(0.253)	
Student characteristics	✗	✓	✓	✓	
Teacher attributes	✗	✗	✓	✓	
Classroom controls	✗	✗	✗	✓	

Notes: The dependent variables include students' test scores in the subjects of math, Chinese, and English, as well as their cognitive ability scores. All scores are standardized to have a mean of zero and a standard deviation of one. All regressions include students' own middle school entry age, leave-out mean of peer middle school entry age within block, and block fixed effects. Student controls include students' gender, minority, rural residence, local residence, only child in family, kindergarten attendance, parental educational attainment, parental occupations, and family income status before students started primary school. Teacher controls include the homeroom teacher's gender, age, teaching experience, educational level, and whether the teacher graduated from a normal university. Classroom controls include class size, leave-out mean of the proportion of female students in the class, and leave-out mean of the proportion of students in the class from high-income families before attending primary school. Standard errors are clustered at the block level and reported in the parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Effects of Peer Age on Student Non-Cognitive Outcomes

Panel A: *Self-Expectations and Confidence*	Expects to obtain a college degree or higher (1)	Expects to pursue a gold- or white-collar profession (2)	Expects to live in first-tier cities or abroad (3)	Self-confidence index (4)	Self-perceives to be very good-looking (5)
Average peer school entry age	-0.277***	-0.135*	-0.174*	-0.153	-0.091**
	(0.060)	(0.072)	(0.103)	(0.121)	(0.043)
Mean of dependent variables	0.867	0.763	0.657	3.040	0.057
Student characteristics	✓	✓	✓	✓	✓
Teacher attributes	✓	✓	✓	✓	✓
Classroom controls	✓	✓	✓	✓	✓
Observations	4937	4863	4512	5146	5131

Panel B: *Health*	Self-perceives to be healthy overall (1)	Mental health index (2)	Engages in weekly physical exercise (3)	Often eats unhealthy food (4)	Often drinks unhealthy beverages (5)
Average peer school entry age	0.080	-0.121	0.023	0.043	0.053
	(0.080)	(0.166)	(0.023)	(0.067)	(0.083)
Mean of dependent variables	0.656	2.161	0.973	0.135	0.214
Student characteristics	✓	✓	✓	✓	✓
Teacher attributes	✓	✓	✓	✓	✓
Classroom controls	✓	✓	✓	✓	✓
Observations	5133	5061	5076	5138	5118

Panel C: *Behaviors and Social Development*	Virtuous behavior index (1)	Disruptive behavior index (2)	Social development index (3)
Average peer school entry age	-0.285*	0.091	-0.180*
	(0.144)	(0.135)	(0.093)
Mean of dependent variables	3.836	1.516	2.981
Student characteristics	✓	✓	✓
Teacher attributes	✓	✓	✓
Classroom controls	✓	✓	✓
Observations	5150	5086	5061

Notes: The dependent variables in Panel A measure students' self-expectations and confidence. The dependent variables in Panel B consist of students' self-reported overall health condition, mental health status, and health-promoting and health-compromising behaviors. The dependent variables in Panel C include students' virtuous behaviors, disruptive behaviors, and social development. All regressions include students' own middle school entry age, leave-out mean of peer middle school entry age within block, and block fixed effects. Student controls include students' gender, minority, rural residence, local residence, only child in family, kindergarten attendance, parental educational attainment, parental occupations, and family income status before students started primary school. Teacher controls include the homeroom teacher's gender, age, teaching experience, educational level, and whether the teacher graduated from a normal university. Classroom controls include class size, leave-out mean of the proportion of female students in the class, and leave-out mean of the proportion of students in the class from high-income families before attending primary school. Standard errors are clustered at the block level and reported in the parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6: Mechanism - Student Effort and Persistence in Study

Panel A: *Student Effort in Study*	Average hours spent on homework assigned by teachers (1)	Average hours spent on homework assigned by parents or tutoring classes (2)	Average hours spent watching TV (3)	Average hours spent on the Internet or playing computer games (4)
Average peer school entry age	-0.309	-0.272	-0.082	0.180
	(0.311)	(0.270)	(0.182)	(0.217)
Mean of dependent variables	2.205	0.656	1.092	0.791
Student characteristics	✓	✓	✓	✓
Teacher attributes	✓	✓	✓	✓
Classroom controls	✓	✓	✓	✓
Observations	5081	5123	5095	5110

Panel B: *Student Persistence in Study*	Persists in attending school even if he/she is ill (1)	Persists in finishing homework that he/she dislikes (2)	Persists in finishing homework that takes a long time (3)
Average peer school entry age	0.020	-0.114**	-0.121***
	(0.056)	(0.049)	(0.042)
Adjusted p-value	[0.724]	[0.033]	[0.016]
Mean of dependent variables	0.873	0.889	0.917
Student characteristics	✓	✓	✓
Teacher attributes	✓	✓	✓
Classroom controls	✓	✓	✓
Observations	5025	5017	5003

Notes: The dependent variables in Panel A measure student effort in study. The dependent variables in Panel B are a series of dummy variables indicating student persistence in study. All regressions include the full set of covariates, including students' own middle school entry age, leave-out mean of peer middle school entry age within block, block fixed effects, student controls, teacher controls, and classroom controls. Panel B also reports the p-values adjusted for potential multiple hypothesis testing issues in brackets. Adjusted p-values are calculated following Newson (2010) and Simes (1986). Standard errors are clustered at the block level and reported in the parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7: Mechanism - Qualities of Students' Friends

	Has ambitious friends who			Has friends with disciplinary issues who				
	perform well in study	are diligent in study	aspire to attend college	skip classes or play truant	violate school regulations	fight at school	smoke or drink alcohol	frequently visit internet cafes or game arcades
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Average peer school entry age	-0.205**	-0.234**	-0.201**	0.009	-0.001	-0.012	0.010	0.031
	(0.091)	(0.098)	(0.096)	(0.016)	(0.016)	(0.016)	(0.014)	(0.019)
Adjusted p-values	[0.028]	[0.028]	[0.028]	[0.733]	[0.956]	[0.733]	[0.733]	[0.551]
Mean of dependent variables	0.484	0.510	0.729	0.010	0.012	0.011	0.009	0.015
Student characteristics	✓	✓	✓	✓	✓	✓	✓	✓
Teacher attributes	✓	✓	✓	✓	✓	✓	✓	✓
Classroom controls	✓	✓	✓	✓	✓	✓	✓	✓
Observations	5111	5103	5091	5096	5095	5098	5101	5102

Notes: The dependent variables are a series of dummy variables capturing the quality of students' best friends. All regressions include the full set of covariates, including students' own middle school entry age, leave-out mean of peer middle school entry age within block, block fixed effects, student controls, teacher controls, and classroom controls. Following Newson (2010) and Simes (1986), we report the p-values adjusted for potential multiple hypothesis testing issues in brackets. Standard errors are clustered at the block level and reported in the parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8: Mechanism - Family Investment

					Parents actively discuss the following issues with their child				
	Child taking private tutoring classes	Checking homework	Helping with homework	Hours spent on the child per day	things happened at school	child's relationship with friends	child's relationship with teachers	child's feelings	child's concerns or worries
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Average peer school entry age	0.028	0.036	-0.028	0.389	0.041	-0.070	0.070	-0.079	-0.097
	(0.082)	(0.093)	(0.083)	(0.693)	(0.053)	(0.061)	(0.043)	(0.064)	(0.063)
Mean of dependent variables	0.337	0.770	0.656	3.340	0.934	0.906	0.924	0.906	0.896
Student characteristics	✓	✓	✓	✓	✓	✓	✓	✓	✓
Teacher attributes	✓	✓	✓	✓	✓	✓	✓	✓	✓
Classroom controls	✓	✓	✓	✓	✓	✓	✓	✓	✓
Observations	5142	5132	5083	4926	5111	5101	5097	5096	5102

Notes: The dependent variables are a series of variables capturing the family's investment in their child's educational, social, and emotional development. All regressions include the full set of covariates, including students' own middle school entry age, leave-out mean of peer middle school entry age within block, block fixed effects, student controls, teacher controls, and classroom controls. Standard errors are clustered at the block level and reported in the parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9: Mechanism - Teacher Inputs

	Math teacher often asks me to answer questions	Chinese teacher often asks me to answer questions	English teacher often asks me to answer questions	Math teacher often praises me
	(1)	(2)	(3)	(4)
Average peer school entry age	0.005	0.080	0.038	0.024
	(0.116)	(0.111)	(0.098)	(0.094)
Mean of dependent variables	0.626	0.648	0.698	0.500
Student characteristics	✓	✓	✓	✓
Teacher attributes	✓	✓	✓	✓
Classroom controls	✓	✓	✓	✓
Observations	5144	5153	5141	5150
	Chinese teacher often praises me	English teacher often praises me	Homeroom teacher often praises me	Homeroom teacher often criticizes me
	(5)	(6)	(7)	(8)
Average peer school entry age	0.165	0.096	-0.073	0.019
	(0.115)	(0.076)	(0.111)	(0.069)
Mean of dependent variables	0.527	0.543	0.505	0.130
Student characteristics	✓	✓	✓	✓
Teacher attributes	✓	✓	✓	✓
Classroom controls	✓	✓	✓	✓
Observations	5144	5153	5136	5134

Notes: The dependent variables are a series of dummy variables indicating how teachers engage and interact with students in class. All regressions include the full set of covariates, including students' own middle school entry age, leave-out mean of peer middle school entry age within block, block fixed effects, student controls, teacher controls, and classroom controls. Standard errors are clustered at the block level and reported in the parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 10: Mechanism - Social Environment at School

	Most classmates are very friendly to me	I can get along with people easily	The atmosphere in my class is good	I often participate in class activities	I feel close to people at school	I feel bored at school
	(1)	(2)	(3)	(4)	(5)	(6)
Average peer school entry age	-0.125***	-0.135**	-0.162*	-0.196*	-0.052	-0.004
	(0.047)	(0.060)	(0.087)	(0.100)	(0.104)	(0.069)
Adjusted p-values	[0.056]	[0.091]	[0.122]	[0.091]	[0.865]	[0.988]
Mean of dependent variables	0.871	0.835	0.826	0.668	0.759	0.123
Student characteristics	✓	✓	✓	✓	✓	✓
Teacher attributes	✓	✓	✓	✓	✓	✓
Classroom controls	✓	✓	✓	✓	✓	✓
Observations	5133	5132	5127	5139	5099	5115

Notes: The dependent variables are a series of dummy variables measuring social environment at school as perceived by students themselves. All regressions include the full set of covariates, including students' own middle school entry age, leave-out mean of peer middle school entry age within block, block fixed effects, student controls, teacher controls, and classroom controls. Following Newson (2010) and Simes (1986), we report the p-values adjusted for potential multiple hypothesis testing issues in brackets. Standard errors are clustered at the block level and reported in the parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix: For Online Publication

Table A1: Test for Sample Attrition

	Probability of Attrition (1)	Probability of Attrition (2)
Average peer school entry age	-0.096	-0.026
	(0.073)	(0.060)
Block fixed effects	✓	✓
Student characteristics	✗	✓
Teacher attributes	✗	✓
Classroom controls	✗	✓
Observations	6815	6815

Notes: The dependent variable is the student's probability of attrition in 8th grade. Standard errors are clustered at the block level and reported in the parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$