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Do peer effects influence the academic performance of rural students at private migrant schools in China?

Shi Min[a,b], Zhouhang Yuan[c], Xiaobing Wang[b], Lingling Hou[b,*]

[a] College of Economics and Management, Huazhong Agricultural University, No.1 Shizishan Street, Hongshan District, Wuhan 430070, China
[b] China Center for Agricultural Policy, School of Advanced Agricultural Sciences, Peking University, No. 5 Yiheyuan Road, Haidian District, Beijing 100871, China
[c] Center for China Grain Research and Training, No.45 Fuxingmennei Street, Xicheng District, Beijing 100801, China

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ABSTRACT

This paper examines peer effects on the academic performance of rural migrant students at both the class level and the individual level. The dataset is from a survey of more than 3000 students from all of the 87 migrant schools in Shanghai and Suzhou, China. The two-stage least squares method with an instrumental variable is employed to control for the endogeneity of peer performance variables. We found that peer effects exist among the migrant students at both class and individual levels. A one-point increase in the average of standardized math grade (SMG) of his/her classmates is associated with an increase of 0.5 points in the SMG of an individual (1.01 standard deviation). A one-point increase in a learning companion's SMG can result in an increase of 0.046 points in the student's SMG. The findings reveal that private migrant schools can improve rural migrant students' academic performance by optimizing students' class allocation and building study groups, providing an additional boost to the input-output efficiency of the human-capital education of the children of migrant workers in China, but the effects of these measures are limited.

1. Introduction

China has experienced unprecedented rural-urban migration, with an increasing number of migrant children moving to urban areas (Li, Han, Zhang, & Rozelle, 2014; Wang, Cheng, & Smyth, 2018). Because of China's *hukou*[1] (household registration) system and limited education resources in the city, migrant children are not unconditionally entitled to enroll in urban public schools (Lai et al., 2014; Wang, Bai, Zhang, & Rozelle, 2017). Although policies have waxed and waned over time regarding the extent to which migrant children are allowed to enroll in urban public schools, the fact is that a large share of migrant children study at private migrant schools (Chen & Feng, 2013; Wang, Luo, Zhang, & Rozelle, 2017), especially in large cities such as Shanghai and Suzhou (Chen & Feng, 2013).

* Corresponding author.
E-mail addresses: min.ccap@pku.edu.cn (S. Min), yuanzh.15s@igsnrr.ac.cn (Z. Yuan), xbwang.ccap@pku.edu.cn (X. Wang), llhou.ccap@pku.edu.cn (L. Hou).

[1] The *Hukou* system is the Chinese household registration system, which creates a spatial hierarchy of urban places, prioritizes the city over the countryside, controls population movement up and down the spatially defined status hierarchy, prevents population flow to the largest cities, enforces the permanent exile of urban residents to the countryside, binds people to the village or city of their birth, and transfers the locus of decision-making with respect to population mobility and work from the transformed household to the work unit (Danwei), specifically, in the countryside, to the lowest unit of the collective (Cheng and Selden, 1994).

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This situation has led to the establishment of private schools for migrant children, which are quite unique in China. Several studies have shown that these schools have poor facilities, high tuition fees and a high teacher-turnover ratio (Chen & Feng, 2013; Goodburn, 2009; Lai et al., 2014). Therefore, there is reason to believe that the quality of education in private migrant schools might be low (Wang, Bai, et al., 2017). Although the poor educational quality and inadequate management of private migrant schools have been seriously criticized, it is undeniable that these schools guarantee migrant children's right to an education, at least to an extent.

Improved school management is supposed to play a significant role in enhancing the human capital of migrant children, and the proper use of peer effects may be one promising instrument for doing so. Peer effects can generate a social multiplier effect because the factors that affect an individual can indirectly affect their peers (Entorf & Lauk, 2008). The effective assignment of peer groups can also help optimize school academic performance, thus promoting the accumulation of human capital. Peer groups tend to form their own unique culture, learning environment and functional mechanisms, all of which influence their attitudes and actions, which in turn affect their behavior and academic performance (Amanda & Rask, 2014; Angrist & Lang, 2004; Brady, Insler, & Rahman, 2015; Carman & Zhang, 2012; Duflo, Dupas, & Kremer, 2011; Kang, 2007; Lefgren, 2004; Li et al., 2014; Lu & Anderson, 2015; Marotta, 2017). One possible mechanism of this approach is that students instruct each other. The second is that it helps reduce classroom disruption and enhance study atmosphere. The third is that it allows teachers to match more accurate instructions to students' specific needs (Vardardottir, 2013).

Although numerous studies have examined peer effects on students' performance, only one such study has focused on children in private migrant schools with poor facilities and less educated teachers (Li et al., 2014). Based on a randomized trial conducted with primary students in private migrant schools in Beijing, Li et al. (2014) found that pairing high- and low-achieving classmates as benchmates improved low achievers' test scores by 0.25–0.3 standard deviations without harming the high achievers, whereas in a separate trial, it was found that offering only low achievers incentives for learning had no effect. Overall, therefore, issues related to peer effects in private migrant schools have been largely overlooked. If peer effects for migrant children in private migrant schools could exist, the formation of small groups within classes or learning partners between students in private migrant schools may provide a feasible way to improve their academic performance. Hence, testing the peer effects in private migrant schools have very important practical implications.

In previous studies, peer effects have been examined at both the grade or class level (Burke & Sass, 2011; Kang, 2007; Lai, 2007; Li et al., 2014) and the individual or group level within a class (Brady et al., 2015; Sacerdote, 2001; Sacerdote, 2011; Song, Loewenstein, & Shi, 2018; Zimmerman, 2003). Average academic performance scores of all other students in a specific grade or class are normally used to test peer effects on an individual's achievement at the grade or class level (Burke & Sass, 2011; Kang, 2007; Lai, 2007; Li et al., 2014). For example, Ding and Lehrer (2007) investigated peer effects at the grade level using the data of high-school students from the 10th to the 12th grade in Jiangsu Province, China, showing that a 1% increase in the average score of other students resulted in 8–15% increases in an individual's score. At the individual level, Lu and Anderson (2015) investigated the peer effects in 7th-grade students at a Chinese junior secondary school. The authors used the characteristics of deskmates and neighboring students (based on gender or average grades) to represent the peer effects of an individual, finding that the presence of a female peer could increase females' scores by 0.20 to 0.30 points.

The findings of previous studies of peer effects on student performance are also mixed (Brady et al., 2015). Most scholars believe that peers with good academic scores tend to have a positive influence on individual academic scores (Hanushek, Kain, Markman, & Rivkin, 2003; Hoxby, 2000; Kang, 2007; Williams & Zimmerman, 2003). However, others find minimal or even negative peer effects on individual academic performance. Using data on medical students from 1996 to 1998, Arcidiacono and Nicholson (2002) found that after controlling the fixed effects of institutions, peer effects had a minimal influence on individual scores. Using data from Boston University, Angrist and Lang (2004) found that peer scores had virtually no influence on individual scores. Meanwhile, peer effects are not static, and there is increasing evidence that peer effects vary by student ability, race, socioeconomic status, and gender (Feng & Li, 2016). Hence, there is a need for additional empirical studies on peer effects in private migrant schools.

With respect to the methods used in assessing peer effects, randomized interventions (Li et al., 2014; Ludwig, Hirschfeld, & Duncan, 2011), natural experiments (Zimmerman, 2003), instrumental variables (Kang, 2007) and fixed-effects models (Hanushek et al., 2003) have been primarily applied in previous studies to control for the peer's self-selection effect and thereby are used to analyze peer effects at the individual level. Although the randomized test approach is ideal to address the issue of selection bias, its implementation is rather difficult and the randomization level is questionable, as the individuals in a controlled group are not sampled from the entire population. Thus, some researchers simulate randomized test conditions in studies related to natural experiments. The natural experiment approach can not only eliminate selection bias but also prevent both the implementation difficulties and the high costs of randomized tests. However, the correct conditions for natural experiments are difficult to find in the real world. Instrumental variables and fixed-effects models are also common options to control for the peer's self-selection effect. Compared to randomized interventions and natural experiments, they are very likely to be conducted. In this study, we use the education level of the peer's parents as the instruments for the peer's performance.

The analysis of this study aims to address the following questions: 1) do peer effects occur in the educational setting of private migrant schools in urban China? and 2) how do peer effects affect student academic performance in these schools? To answer these questions, survey data from more than 3000 students at 87 migrant schools in Shanghai and Suzhou, Jiangsu Province, are used. The two-stage least squares method with the instrumental variable is employed to control for the endogeneity of peer performance. The answers to the questions raised have important policy-related and practical significance with respect to optimizing the allocation of local education resources and increasing the effectiveness of investment of rural human resources. This study also adds to the limited literature examining peer effects on the academic performance of rural students at private migrant schools.

In the next section, we present our empirical models to examine peer effects on student academic performance at both the class

and the individual levels. Section 3 shows the data source and provides a descriptive analysis of the key variables. Our estimation results and discussions are shown in Section 4. The final section concludes the paper.

2. Method

Referencing previous studies on peer effects, in this study we propose to examine peer effects on student academic performance in private migrant schools at both the class and the individual levels. Peer effects in education generally refer to the ability, characteristics, and differences of the peer groups that compose the student's school, class, or study group and that may have significant effects on individual students' academic performance and other behaviors. Accordingly, this study will first assess peer effects at the class level, that is, it will empirically test the impact of the average academic grades of classmates on an individual student's outcome. Second, at the individual level, we attempt to quantify the effect of a learning companion's academic grade on an individual student's grade. Here, the learning companion is defined as the most important classmate in the same class who always learns together with him/her, and the learning companion discuss the questions in the homework and lectures; they may also exchange curricular tutorial books and extracurricular reading books, or take the tutorial together. Furthermore, the definition also highlight that the learning companion is the most important one within the same class. In the survey process, before the students filled the survey form, the enumerator explain the key questions for the student. If the students have questions about the survey, they feel free to raise the hand and the enumerators will try to explain personally again to help the students fill in the questions. For the simplicity, a learning companion is equivalent of a study partner and a peer in the rest of the paper.

As the possible mutual influence between a student's and his/her learning companion's academic performance, there is a potentially endogenous issue that arises when we directly assess the impact of a learning companion's academic grades on a student's outcome. To address the potential simultaneity bias and endogeneity issue, we use the instrumental variable approach. We propose to use the education levels of the companion's parents as the instrumental variables (IVs) for the academic performance of the companion. Intuitively, although the proposed IVs should have a significant impact on the companion's academic performance, it is impossible for them to have a direct effect on the student's outcome. Hence, we arrive at hypothesis (a): the proposed IVs are valid to control for the endogeneity in the analysis.

To separate peer effects from other confounding influences to the greatest extent possible, the model of an individual student's academic grade controls for the self-selection effects, school effects, and impact of teachers (Carman & Zhang, 2012; Wang, Bai, et al., 2017). By doing so, we further propose the second and third hypotheses: (b) the average academic grade of classmates significantly and positively influences an individual student's outcome, and (c) a learning companion's academic grade has a significantly positive impact on an individual student's outcome. Thereby, the approval of (b) and (c) will confirm the existence of peer effects at the class and individual levels, respectively.

The empirical model used to examine the peer effects on a student's academic performance at the class level can be expressed as follows:

$$y_{ics} = \alpha_0 + \alpha_1 \overline{class_{ics}} + \alpha_2 X_i + \alpha_3 T_c + \alpha_4 S_s + \varepsilon_{ics} \quad (1)$$

where y_{ics} represents the academic grade of student i in class c of school s, whereas $\overline{class_{ics}}$ denotes the average academic grade of all the other students in the entire class in class c of school s, excluding student i. The vectors X, T, and S denote the characteristics of student and family, teachers and school quality, respectively, and thereby are used to capture the effects of self-selection, school, and teachers on the i^{th} student's academic outcome. $\alpha_0 \ldots \alpha_4$ are parameters to be estimated, and ε is the error term. Because that the average academic grade of classmates ($\overline{class_{ics}}$) is an exogenous variable for the individual's outcome (y_{ics}), the estimation of model (1) can be performed directly through the ordinary least squares (OLS) method. Accordingly, parameter α_1 can reveal the impact of peer effect at class level on the academic outcome variable y_{ics}.

To assess peer effects on a student's academic performance at the individual level, we establish the following model:

$$y_{ics} = \beta_0 + \beta_1 peer_{ics} + \beta_2 X_i + \beta_3 T_c + \beta_4 S_s + u_{ics} \quad (2)$$

where $peer_{ics}$ represents the academic grade of a learning companion who has been identified by student i as a regular study partner in class c of school s. $\beta_0 \ldots \beta_4$ are parameters to be estimated, and u is the error term.

As discussed above, $peer_{ics}$ in Eq. (2) is an endogenous variable. The direct use of the OLS method in model (2) would result in an estimation bias. Therefore, a Two-Stages Least Square (2SLS) method with the IV is further applied in the study. Thus, in the first stage, $peer_{ics}$ is further expressed as follows:

$$peer_{ics} = \theta_0 + \theta_1 parents_{ics} + \theta_2 X_i + \theta_3 T_c + \theta_4 S_s + \epsilon_{ics} \quad (3)$$

where the IV $parents_{ics}$ is the education level of a learning companion's parents. $\theta_0 \ldots \theta_4$ are parameters to be estimated, and ϵ is the error term. Moreover, the IVs are supposed to meet the conditions $\mathrm{Cov}(parents_{ics}, peer_{ics}) \neq 0$ and $\mathrm{Cov}(parents_{ics}, u_{ics}) = 0$. The validity of the IVs is tested by the following empirical analysis. According to Eq. (3), we can further obtain the fitted values ($\widehat{peer_{ics}}$ and $\widehat{\epsilon_{ics}}$) of $peer_{ics}$ and ϵ_{ics}, respectively.

In the second-stage regression, $\widehat{peer_{ics}}$ and $\widehat{\epsilon_{ics}}$ are incorporated into Eq. (2), and thereby the model of a student's academic performance could be re-expressed as follows:

$$y_{ics} = \beta'_0 + \beta'_1 \widehat{peer_{ics}} + \beta'_2 X_i + \beta'_3 T_c + \beta'_4 S_s + (u'_{ics} + \beta'_1 \widehat{\epsilon_{ics}}) \quad (4)$$

where $\beta'_0 \ldots \beta'_4$ are parameters to be estimated, and u' is the error term. The coefficient of $\widehat{peer_{ics}}$ reflects the impact of a learning

companion's academic performance on a student's outcome.

Finally, to confirm the robustness of the estimation results, a stepwise regression approach is used for the estimations of Eq. (1) and Eqs. (3) and (4). The valid test for the IVs is also applied after the estimation of 2SLS for Eqs. (3) and (4). A weak identification test for all the IVs is implemented by calculating the Cragg-Donald Wald F statistic and comparing with the Stock-Yogo weak ID test critical values, and the Sargan Statistic is used for an overidentification test of all instruments.

3. Data

3.1. Data source

The data used in this study are from a 2014 rural migrant student survey in Shanghai and Suzhou, Jiangsu Province. During the survey, to establish a representative dataset of private migrant schools in Shanghai and Suzhou, we contacted all the educational and research institutes and non-profit organizations in the two cities that might have contact information for private migrant schools in Shanghai and Suzhou, and we then called each school to confirm that it was still operating (Wang, Bai, et al., 2017; Wang, Luo, et al., 2017). Accordingly, all 87 private migrant schools in that sampling frame were our sample schools. Later, one fifth-grade class was randomly chosen from each private migrant school,[2] and all of the students in the sample class were our sample students. It is noted that all the sample students here were the children of migrant workers and none of them were from local urban households. Finally, our sample was composed of 3188 migrant students in fifth-grade classes from all 87 private migrant schools in Shanghai and Suzhou, Jiangsu Province.

To ensure the comparability of the assessments of levels of learning between students in Shanghai and students in Suzhou, the survey was conducted in both cities at the same time (the first two weeks of May 2014). The survey can be divided into two modules. The first module covered information on the school's facilities and information, the number and quality of the teaching staffs, and the characteristics of students and family members. As a cross-check, homeroom teachers were asked to assist in verifying the information provided by each student (Wang, Bai, et al., 2017).

The second module was designed to carry out grade-specific standardized mathematics tests for the sample students. Following previous studies (Betts, 2004; Burke & Sass, 2011; Duflo et al., 2011; Song et al., 2018), math was chosen for testing. Based on the items of the TIMSS,[3] the test was designed with the assistance of local educators. The examination lasted for 25 min and was supervised by enumerators at each school. The exams were graded by our research team. The scores were normalized by subtracting the overall mean and dividing by the overall standard deviation. The normalized approach not only maintained the relative positions/rankings of the test scores of all students but also transformed the variable into a more readily interpretable form (that is, in SDs).

3.2. Descriptive statistics of key variables

The dependent variable is a student's standardized math grade (SMG) with a mean of 0.02 and a standard deviation of 1.01. The frequency distribution of all students' SMG is shown in Fig. 1, showing an approximately normal distribution. Additionally, as shown in the scatter plot in Fig. 2, a student's SMG is positively correlated with the average SMG of other students in the class. Fig. 3 also shows a positive correlation between a student's SMG and her/his learning companion's SMG. Therefore, peer effects seem to exist at both the class and the individual levels without controlling other variables that may affect students' academic performance.

Students in the same peer group are spatially and temporally close, which makes the common shocks an important problem during the identification of peer effects. On average, migrant children come from ten provinces in a class. Lai et al. (2014) also indicated that the migrant students are also mobile as their parents and there exists the deteriorating performance over time. Due to the limitation of our data, we are not able to test the duration of the peer effect on the student's academic performance. There also exists one student who is the companion of two other students at the same time.[4] The appendix Table A3 presents the statistics of the distribution of the peer. Less than one third of the peer matched with more than two migrant students. Another one third of the peer matched with two students. When keeping one-to-one student with his/her peer, the samples turns to be 1263 observations.

Table 1 summarizes the definitions and statistics of all other variables used in the empirical analysis. The characteristics of students and their households ($\boldsymbol{X}$) consist of student gender, age, whether the student is an only child, family size and the education levels of the parents. The average age of the sample students was approximately 11 years old, and 53% of them were male. Only 18% of migrant students were only children, and on average, each household has almost five family members. The proportions of students' fathers and mothers with a high-school education or above were 60% and 40%, respectively.

The eigenvector ($\boldsymbol{S}$) represents the essential characteristics of the school and the class, including how many years the school had been in operation, the percentage of credential primary school teachers in the school's teaching staff, class size and the ratio of male to female students in a class. The oldest established private migrant school has been operating for 25 years, and the newest one has

[2] The reason for choosing fifth-grade students is both because we believe students of this age have the ability to answer questions about the nature of their home environment and their parents' occupation and educational background and because we had developed standardized testing materials to assess the math performance of fifth-grade students (Wang et al., 2017b).

[3] Details about the TIMSS can be found at http://timss.bc.edu/home/pdf/TP_About.pdf.

[4] Thank for the comment from the anonymous referee.

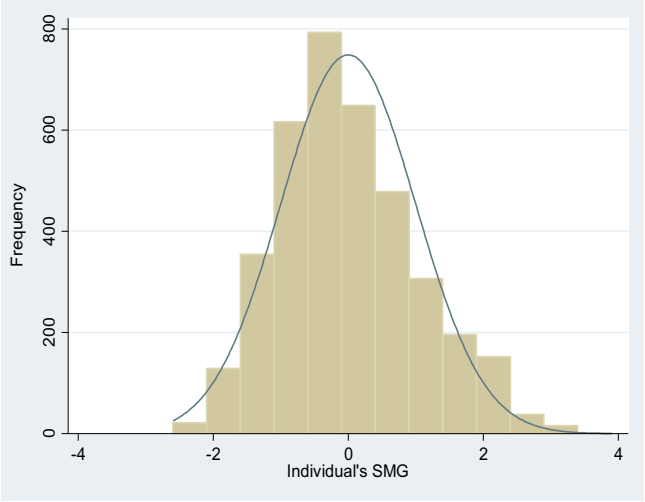

Fig. 1. Frequency distribution of students' SMG.

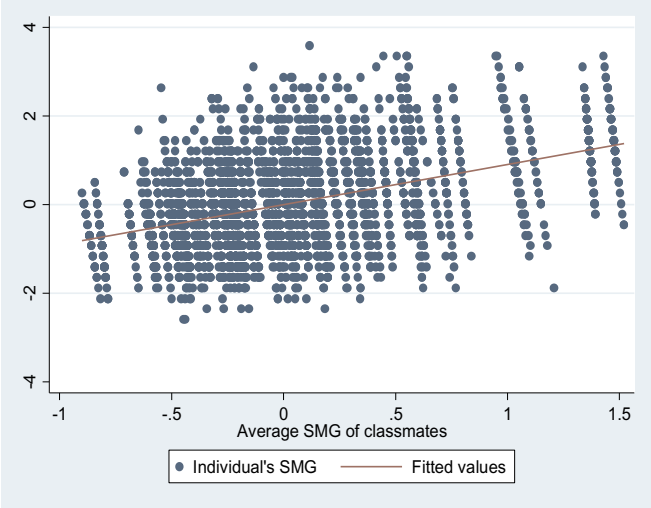

Fig. 2. Correlation between an individual's SMG and classmates' average SMG.

been operating for only one year. The average age of all schools was approximately 11 years. Only 32% of the school's teaching staffs were credential primary school teachers. On average, each class had 47 students, and the ratio of male to female students was 1.27.

The teacher eigenvector (***T***) includes the gender, age, and title of the head teacher of the student's class, along with whether the head teacher was a math teacher. Approximately 29% of head teachers of the sample classes were male, a percentage that is much lower than the percentage of female head teachers. The average age of head teachers was approximately 35 years old. Approximately 26% of head teachers taught math, and only 29% of head teachers had certificates for primary school teaching at level one and above.

4. Estimation results

To empirically examine the existence of peer effects on students' academic performances at private migrant schools, we performed estimations for Eqs. (1), (3) and (4). First, using OLS and stepwise regression approaches for Eq. (1), the peer effects of all the other students in the class on individual academic performance were tested (Table 2). Second, the 2SLS method and was used to estimate Eqs. (3) and (4) so that peer effects of a learning companion on an individual student's SMG could be quantitatively identified (Tables 3 and 4).

As shown in Tables 2, 3 and 4, column a) reports the estimation results of peer effects under the condition of controlling for the characteristics of students and their households (self-selection effect). Next, the control variables were added in a stepwise manner, including the characteristics of schools and classes (column b) and head teachers (column c). Column c) presents the estimation results of peer effects by controlling for all the other variables. Finally, column d) in Tables 3 and 4 reports the estimation results by

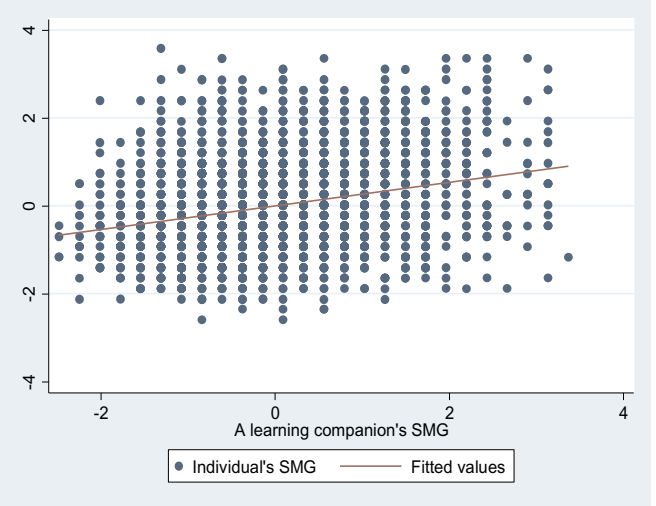

Fig. 3. Correlation between individual's SMG and her/his learning companion's SMG.

Table 1
Summary statistics of key variables.

Variable	Mean	Std. Dev.	Min	Max
Dependent variables				
y: Individual's standardized math grade (SMG)	0.02	1.01	−2.60	3.59
X: characteristics of students and their families				
Age (Year)	11.06	0.95	8	14
Gender (1 = Male; 0 = Female)	0.53	0.50	0	1
Single child (1 = Yes; 0 = Otherwise)	0.18	0.38	0	1
Hhsize (Number of family members, excepting the child)	4.64	1.22	2	8
Education of father (1 = High school or above; 0 = Otherwise)	0.60	0.49	0	1
Education of mother (1 = High school or above; 0 = Otherwise)	0.40	0.49	0	1
S: characteristics of schools and classes				
Established years (How many years the school has been in operation; Year)	11.09	4.66	1	25
Credential teachers (% of Credential primary school teachers on the school's teaching staff)	32	45	0	100
Male-female ratio in the class	1.27	0.39	0.55	2.44
Class size (Number of students in the class)	47.19	8.94	24	69
T: characteristics of head teachers				
Gender (1 = Male; 0 = Female)	0.29	0.45	0	1
Age (Year)	34.59	10.29	22	60
Job title (1 = Primary school teacher at level one and above; 0 = Otherwise)	0.29	0.45	0	1
Math teacher (1 = Yes; 0 = Otherwise)	0.26	0.44	0	1

Source: Authors' survey.

the specifications controlling for the class fixed effects and the characteristics of student and family.

Moreover, as shown at the bottom of Tables 2, 3 and 4, all the F-test and Wald chi2 test statistics are significant at the 1% level, illustrating the significant overall explanatory power of the dependent variables across the models. Most variables are significantly different from zero, validating the specification of our empirical models. More details on the estimation results are presented as follows.

4.1. Peer effects at the class level

The estimation results shown in Table 2 suggest that average SMG of classmates has a significant and positive impact on an individual's SMG regardless of the specifications of a), b) and c). Under the condition that all independent variables are controlled (column c), the SMG of individuals increases 0.499 points with every 1-point increase in the average SMG of classmates, or almost half of a standard deviation (1.01). The results reveal that the increase in the average SMG of classmates has a significant lifting effect on an individual student's SMG. Therefore, the results prove that there are significant and positive peer effects on a student's academic performance in private migrant schools at the class level.

Most independent variables concerning the characteristics of students and their parents, including a student's age, whether the student is an only child, and the education levels of the parents have significant impacts on the student's SMG, confirming that the

Table 2
Impact of average SMG of classmates on a student's academic performance.

	Individual's SMG		
	a)	b)	c)
Peer effects			
Average SMG of classmates	0.506***	0.516***	0.499***
	(16.08)	(15.71)	(15.20)
Characteristics of students and their families			
Age	−0.059***	−0.062***	−0.052***
	(4.15)	(4.34)	(3.70)
Gender	0.018	0.025	0.023
	(0.69)	(0.97)	(0.89)
Single child	−0.080**	−0.079**	−0.083**
	(2.29)	(2.21)	(2.33)
Hhsize	−0.008	−0.010	−0.008
	(0.76)	(0.85)	(0.69)
Education of father	0.822***	0.822***	0.816***
	(28.17)	(28.20)	(28.07)
Education of mother	0.584***	0.589***	0.591***
	(17.34)	(17.51)	(17.71)
Characteristics of schools and classes			
Established years		0.001	0.000
		(0.21)	(0.13)
Credential teachers (%)		−0.028	−0.016
		(0.19)	(0.11)
Male-female ratio		−0.042	−0.009
		(1.28)	(0.26)
Class size		−0.004**	−0.005**
		(2.43)	(3.35)
Characteristics of head teachers			
Gender			0.024
			(0.80)
Age			−0.003**
			(2.21)
Job title			0.214***
			(6.72)
Math teacher			0.026
			(0.90)
Constant	−0.015	0.249	0.174
	(0.09)	(1.29)	(0.87)
F -value	498.75***	320.61***	246.83***
R^2	0.513	0.514	0.523
Adjusted R^2	0.512	0.513	0.521
Obs.	3188	3188	3188

Note:***, ** and * represents the significance level at 1%, 5%, and 10%, respectively; the absolute t-value calculated using robust standard errors is reported in parentheses.

self-selection effect plays an important role in a student's academic performance in private migrant schools. Interestingly, given that all the interviewed students were in fifth grade, the older students tend to have a lower SMG. The reason for this finding might be that older students in the same grade may have lower learning capacities; this is also a reason that they stay in the same grade as younger students. A student who is an only child is more likely to have a lower SMG. One possible reason for this finding is a lack of peer interaction at home. Furthermore, both fathers' and mothers' education levels have a positive impact on the academic performance of private migrant school students; parents with higher education levels can improve students' academic performance through family education. This finding also reveals that knowledge can be passed down intergenerationally through family education.

With respect to the school effect, class size negatively influences a student's outcome in private migrant primary schools, but the effect is small. One more student in the class results in a decrease of 0.005 in the student's SMG. Similarly, the age of the head teacher has a slightly negative impact on a student's SMG. A head teacher with a certificate for primary school teaching at level one and above will result in a 0.234-point increase in a student's SMG, which is almost one-fourth of a standard deviation. This finding highlights the importance of improving teachers' qualities in increasing the efficiency of education investment in private migrant schools.

4.2. Peer effects at the individual level

Tables 3 and 4 report the estimation results of 2SLS for peer effects on a student's SMG in private migrant schools at the individual level. To control for the endogeneity of a learning companion's academic performance in explaining the student's outcome, we use the

Table 3
First-step results of the 2SLS regression on the impact of a learning companion on a student's academic performance.

	The learning companion's SMG			
	a)	b)	c)	d)
IV_1:Education of a learning companion's mother	0.640***	0.640***	0.636***	0.550***
	(18.52)	(18.65)	(18.64)	(16.47)
IV_2:Education of a learning companion's father	0.693***	0.690***	0.689***	0.629***
	(21.01)	(20.98)	(21.11)	(19.41)
Characteristics of students and their families				
Age	−0.035**	−0.035**	−0.031**	−0.026*
	(2.34)	(2.39)	(2.09)	(1.84)
Gender	0.096***	0.110***	0.107***	0.101***
	(3.34)	(3.80)	(3.76)	(3.72)
Single child	−0.006	−0.020	−0.022	−0.013
	(0.15)	(0.52)	(0.56)	(0.32)
Hhsize	−0.005	−0.002	−0.004	−0.001
	(0.40)	(0.18)	(0.29)	(0.08)
Education of father	0.182***	0.181***	0.173***	0.094**
	(5.47)	(5.47)	(5.27)	(2.99)
Education of mother	0.065*	0.062*	0.060*	−0.021
	(1.93)	(1.83)	(1.81)	(0.67)
Characteristics of schools and classes				
Established years		−0.005	−0.005*	
		(1.53)	(1.69)	
Credential teachers (%)		0.549***	0.467**	
		(3.30)	(2.78)	
Male-female ratio		−0.113**	−0.134***	
		(2.86)	(3.23)	
Class size		−0.001	−0.002	
		(0.60)	(1.16)	
Characteristics of head teachers				
Gender			−0.049	
			(1.43)	
Age			−0.003*	
			(1.80)	
Job title			−0.028	
			(0.88)	
Math teacher			0.208***	
			(6.48)	
School fixed effects				Controlled
Constant	−0.578***	−0.343	−0.221	−0.222
	(3.20)	(1.64)	(1.01)	(0.96)
F-value	831.22***	818.47***	811.69***	33.27***
Centered R^2/ R^2	0.483	0.485	0.497	0.459
Un-centered R^2/ Adjusted R^2	0.483	0.485	0.497	0.459
Obs.	3188	3188	3188	3188

Note: ***, ** and * represents the significance level at 1%, 5%, and 10%, respectively; the absolute t-value calculated using robust standard errors is reported in parentheses.

education levels of the learning companion's parent as IVs in the first stage. The estimated results of the first-stage regression indicate that the education levels of the learning companion's father and mother always significantly and positively affect the learning companion's academic performance across the three specifications a), b), c) and d).

To confirm the validity of the proposed IVs, we also performed a series of tests after the estimation of 2SLS for Eqs. (3) and (4). First, the results of Hausman test validate the use of the IVs. Second, we use the Cragg-Donald Wald F statistic and the Stock-Yogo weak ID test critical values to test whether weak identification occurs in the IVs. The test results always reject the null hypothesis of weak identification at the 1% significance level, regardless of the specifications of a), b), c) and d). Third, the Sargan Statistic is used to test whether over-identification occurs in the IVs. The test results for the specifications of a), b), c) and d) also find that the IVs used in this study do not have over-identification issues. Finally, a falsification test is employed to further check for the validity of the IVs. The results of falsification test show that the used IVs significantly affect an individual student's academic performance, but did not directly affect the academic performance of the peer (Appendix Table A1). Hence, the IVs are proved to be exogenous. Consistent with our intuitive analysis, the empirical results also confirm that the proposed IVs in this study are valid.

Table 4 reports the second-step estimation results of the 2SLS regression for the peer effects at the individual level. The results show that a learning companion's SMG always has a significant and positive effect on a student's SMG, consistent with the results at the class level. After controlling for the variables regarding the characteristics of individual, family, school and head teachers, the

Table 4
Second-step results of the 2SLS regression on the impact of a learning companion on a student's academic performance.

	Individual's SMG			
	a)	b)	c)	d)
Peer effects				
The learning companion's SMG	0.139***	0.139***	0.130***	0.046*
	(6.07)	(5.99)	(5.62)	(1.72)
Characteristics of students and their families				
Age	−0.066***	−0.067***	−0.054***	−0.063***
	(4.58)	(4.61)	(3.81)	(4.34)
Gender	0.004	0.013	0.011	0.018
	(0.15)	(0.48)	(0.42)	(0.69)
Single child	−0.061*	−0.067*	−0.073**	−0.057
	(1.70)	(1.83)	(2.00)	(1.52)
Hhsize	−0.004	−0.008	−0.006	−0.009
	(0.34)	(0.73)	(0.51)	(0.79)
Education of father	0.864***	0.863***	0.853***	0.813***
	(28.67)	(28.63)	(28.56)	(27.95)
Education of mother	0.644***	0.642***	0.643***	0.582***
	(18.60)	(18.63)	(18.86)	(17.71)
Characteristics of schools and classes				
Established years		−0.001	−0.001	
		(0.06)	(0.21)	
Credential teachers (%)		0.324**	0.282**	
		(2.16)	(1.90)	
Male-female ratio		−0.075**	−0.033	
		(2.16)	(0.93)	
Class size		−0.001	−0.002	
		(0.43)	(1.47)	
Characteristics of head teachers				
Gender			−0.010	
			(0.31)	
Age			−0.003**	
			(2.21)	
Job title			0.238***	
			(7.11)	
Math teacher			0.092***	
			(3.11)	
School fixed effect				Controlled
Constant	0.001	0.122	0.036	0.148
	(0.01)	(0.62)	(0.18)	(0.74)
Wald chi2	3174.19***	3200.55***	3362.77***	43.30***
R^2	0.482	0.483	0.495	0.536
Obs.	3188	3188	3188	0.536

Note:***, ** and * represents the significance level at 1%, 5%, and 10%, respectively; the absolute t-value calculated using robust standard errors is reported in parentheses.

marginal effect of the learning companion's SMG on individual scores is 0.130, meaning that a 1-point increase in a learning companion's SMG can result in a 0.13-point improvement on the individual's SMG. Therefore, a student's SMG can be affected by learning interaction with her/his learning companion, and if her/his learning companion's SMG increases, the student's academic performance would also correspondingly improve. Therefore, the results confirm the existence of peer effects on a student's academic performance at the individual level.

The characteristics of individual, family, school and head teachers affect the student's academic performance to different extents. Consistent with the findings from Table 2, a student's age, whether the student is an only child, the education levels of the parents, and the age of the head teacher always have significant impacts on the student's SMG. Additionally, the quality of teachers in private migrant schools plays an essential role in a student's academic performance. In line with the positive impacts of head teachers with a certificate for primary school teaching at level one and above on individuals' grades, a higher percentage of credential primary teachers among the school's entire retinue of teachers is also conducive to improving the SMG of students.

To control for the variables that simultaneously affect the academic performance of a student and peer (or students from the same class) as much as possible, the class fixed effect is further included in column d). By doing so, most unobserved determinations that may simultaneously affect the academic performance of a student and peer could be eliminated. Consequently, while the marginal effect of the learning companion's SMG on individual scores is 0.046, weaker than the original result (0.130), the sign is still consistent with our main findings.

4.3. Discussions

Empirical studies have shown heterogeneous peer effects on a student's academic performance under different circumstances (Betts, 2004; Brady et al., 2015; Burke & Sass, 2011; Duflo et al., 2011; Kang, 2007; Lefgren, 2004; Marotta, 2017; Vigdor & Nechyba, 2006; Zeneli, Thurston, & Roseth, 2016); even in a seemingly consistent academic setting across schools in China, peer effects are quite different (Carman & Zhang, 2012; Ding & Lehrer, 2007; Feng & Li, 2016; Lai, 2007; Lu, 2014; Song et al., 2018; Wang et al., 2018). However, peer effects in private migrant schools have been largely ignored in previous studies. This study is the first to empirically examine peer effects in private migrant schools at both the class and individual levels. The findings indicate that under the condition that the characteristics of individual, family, school and head teachers are controlled, the SMG of individuals increases 0.499 (0.13) points with every 1-point increase in the average SMG of classmates (in the learning companion's SMG). However, the peer effect of the learning companion is just 0.046 after controlling for the school fixed effect, weaker than most of previous studies (e.g. Ding and Lehrer, 2007; Li et al., 2014). Therefore, the finding of this study on peer effects in private migrant schools is essential and can complement the relevant empirical evidence.

Because prior studies indicate that both native-to-native and migrant-to-migrant peer effects are higher in ability-differencing school systems than in comprehensive schools, non-comprehensive school systems may magnify the prevailing educational inequality between students with a low parental socioeconomic migration background and children from more privileged families (Entorf & Lauk, 2008). Moreover, in a comprehensive school that includes both rural migrant students and urban students, a higher proportion of migrant students in the class overall has a positive, rather than a detrimental, effect on local students' academic achievement (Wang et al., 2018). Accordingly, a better understanding of peer effects in private migrant schools should contribute to optimizing the allocation of local education resources to reduce the educational disparities between private migrant schools and urban public schools that is not limited to helping to optimize students' class allocation and build study groups.

Consistent with previous studies (Burke & Sass, 2011; Feng & Li, 2016; Wang, Bai, et al., 2017), this study confirms that the SMG of a study partner has a significantly positive effect on the SMG of an individual student. Specifically, under the condition that individual, family and the fixed effect of schools were controlled (column d, Table 4), the SMGs of individuals increased 0.046 points with 1-point increase in the SMGs of study partners. However, the peer effects revealed in our results were much weaker than in Kang (2007), which observed a 0.31 point increase in individual scores with 1-point increase in peer mathematics scores. This finding implies although there exist positive peer effects in private migrant schools, it may be not an effective way to improve student academic performance in private migrant schools through maximizing peer effects in school learning.

The findings of this study also highlights the importance of family and school education in student academic performance at private migrant schools (Table 4). Notably, the marginal effect of the father's education level on a student's SMG is approximately 0.813, which is 0.31 higher than the marginal effect of the mother's education level (Column d). If the education level of a migrant student's father (mother) is high school or above, the student's SMG is 0.813 points higher than his or her current grade. Therefore, the parents' education levels have positive effects on the academic performance of rural primary school students; parents with higher education levels can improve student academic performance through family education. Moreover, both the overall quality of teachers in private migrant schools and the quality of the head teacher positively affect a student's academic performance. Improving teacher quality in private migrant schools represents an important measure of improving student academic performance and will benefit the cultivation of the human capital of migrant children.

4.4. Robustness check

To further make sure the solidity of our main findings in this study, we conduct several robustness checks using alternative specifications. First, considering that the education levels of a couple (IVs) are correlated, this may affect the judgment of the validity of the IVs. We also separately make use of the education level of the father or the mother as an instrument variable.[5] Accordingly, all of the results of Hausman test, weak identification and falsification test consistently confirm the validity of the separate IVs. The marginal effect of the learning companion's SMG on individual scores is significantly 0.052 when the mother's education level is used as an IV, while it is insignificantly 0.040 when the father's education level is used as an IV (Appendix Table A2). This result reveals that the magnitudes and significances of peer effects are heterogeneous under different IVs, while both directions of the coefficients regarding peer effects are consistent with our main findings. Compared with the different estimation results between using the mother's and the father's education level as an IV, the estimate using the parents' education levels appears to lower the estimation of peer effects.

Our second specification allows to control for the cluster of class to obtain cluster-robust standard errors.[6] In addition to the magnitudes of standard errors, the estimation results do not have any change as compared with the results presented in Tables 2, 3 and 4. Here the re-estimation results are omitted but could be provided upon request.

Considering there exists one student who is the learning companion of two or more other students at the same time, the appendix Table A3 presents the statistics of the distribution of the peers. To check the robustness of our results, we have kept the one-to-one student with his/her peer. Based on the remaining samples (1263 observations), we re-estimate the model established in this study. As shown in Table A4, A5 and A6, the peer effects on an individual student's academic performance are always significant, confirming

[5] Thanks for the suggestion of the anonymous reviewer.

[6] We thank the anonymous reviewer's comment.

the robustness of our main findings. Nevertheless, the magnitudes of peer effects in Table A4, A5 and A6 are also relatively high as compared to our main results but still lower than most of previous studies.

5. Conclusions and discussion

The education of rural migrant children is critical to the development of rural human capital and rural development in China. Using survey data collected from 3188 students at 87 migrant schools in Shanghai and Suzhou, Jiangsu Province, this study examines peer effects on students' standardized math scores in private migrant schools at both the class level and the individual level. The results suggest that the average standardized math grade of classmates has significantly positive effects on an individual's outcome. The education levels of a learning companion's parents are valid instrumental variables for the standardized grade of the learning companion in explaining the academic performance of a student. Accordingly, the standardized math grade of a learning companion also positively affects an individual's academic performance. Therefore, peer effects indeed matter in student academic performance at migrant children's schools at both the class and the individual levels.

Because there are heterogeneous peer effects on a student's academic performance in schools under various circumstances, this study uniquely fills a research gap concerning peer effects in private migrant schools in China. The positive peer effects suggest that private migrant schools could improve rural migrant students' academic performance by optimizing students' class allocation and building study-pair groups, further boosting the input-output efficiency of the human-capital educations of the children of migrant workers in China and reducing the inequality of education between private migrant schools and urban public schools, at least to some extent. However, the peer effects are weak in private migrant schools, implying that these measures may not achieve the desired results.

The results of this study have important practical significance for parents, teachers and various sectors of society. Rural migrant children are part of the workforce that will develop the nation and society in the future and will make an important contribution to both urbanization and agricultural modernization. Focusing on the education-related issues experienced by rural migrant students is not merely a question of taking responsibility for the education and healthy development of these children; it also implies taking responsibility for the establishment and development of an inclusive and fair education system in China. The education quality of rural migrant students has a crucial function in boosting both the accumulation of rural human capital and the stability of society. Therefore, it is necessary to implement effective measures to improve the educational quality of private migrant schools, thereby increasing the returns on their investment in human capital.

Based on our study's findings, we would like to offer the following policy recommendations. First, educational outcomes could be further improved through the formation of small groups within classes or “study partners” between students in private migrant schools. This approach could promote higher student scores through student interaction (e.g., good study habits, discussions of questions, knowledge spillovers) and mutual encouragement and influence (Ding & Lehrer, 2007; Marotta, 2017; Wang et al., 2018). Second, it is recommended that teachers maximize peer effects. While the effect of this measure is limited, it it undeniable to be a feasible way and easy to implement. For example, assigning seats based on the academic scores of students instead of merely by height and gender would help improve student performance through peer effects. Third, measures should be taken to increase the threshold of auditing for teachers and teacher quality in private migrant schools. For example, increasing the qualification requirements for head teachers and increasing the percentage of Credential primary school teachers on the school's teaching staff would have a significant impact on the cultivation of the human capital of rural migrant workers' next generation. Finally, the educational level of rural migrant students' families also merits consideration. In particular, family education provided by parents with educational levels of high school and above could supplement school education to improve students' academic performance.

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Appendix A. Appendix

Table A1
The results of a falsification test for the exogeneity of IVs.

Variable	Individual's SMG	The learning companion's SMG
Individual's SMG		0.058**
		(2.53)
Education of father	0.816***	0.014
	(26.86)	(0.32)
Education of mother	0.582***	−0.029
	(19.13)	(0.70)
Control for all the other variables	Yes	Yes
School fixed effects	Yes	Yes

(*continued on next page*)

Table A1 (*continued*)

Variable	Individual's SMG	The learning companion's SMG
Constant	0.189***	0.872***
	(0.90)	(3.29)
F-value	38.66***	10.85***
R^2	0.521	0.223
Obs.	3188	3188

Note:***, ** and * represents the significance level at 1%, 5%, and 10%, respectively; the absolute t-value calculated using robust standard errors is reported in parentheses.

Table A2
Second-step results of the 2SLS regression on the impact of a learning companion on a student's academic performance using different IV.

Variables	Using IV_1:Education of a learning companion's mother	Using IV_2:Education of a learning companion's father
	Individual's SMG	Individual's SMG
Peer effects		
The learning companion's SMG	0.052*	0.040
	(1.74)	(1.32)
Control for all the other variables	Yes	Yes
School fixed effects	Yes	Yes
Constant	0.142	0.153
	(0.71)	(0.76)
F -value	43.12***	43.41***
R^2	0.536	0.536
Obs.	3188	3188

Note:***, ** and * represents the significance level at 1%, 5%, and 10%, respectively; the absolute t-value calculated using robust standard errors is reported in parentheses.

Table A3
Distribution of the match status between learning companions and students.

Number of learning companions	Number of the matched students	Observations	Percent (%)
1	1	1263	39.62
1	2	1058	33.19
1	3	457	14.43
1	4	262	8.22
1	5	108	3.39
1	6	24	0.75
1	8	16	0.50
Total		3188	100

Table A4
Impact of average SMG of classmates on a student's academic performance.

	Individual's SMG		
	a)	b)	c)
Peer effects			
Average SMG of classmates	0.453***	0.459***	0.438***
	(10.81)	(10.70)	(10.23)
Characteristics of students and their families			
Age	−0.067***	−0.070***	−0.061***
	(2.89)	(2.98)	(2.64)
Gender	0.006	0.011	0.012
	(0.15)	(0.26)	(0.28)
Single child	−0.131**	−0.131**	−0.136**

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Table A4 (*continued*)

	Individual's SMG		
	a)	b)	c)
	(2.31)	(2.25)	(2.35)
Hhsize	0.020	0.021	0.024
	(1.05)	(1.08)	(1.27)
Education of father	0.827***	0.829***	0.821***
	(17.61)	(17.72)	(17.44)
Education of mother	0.584***	0.585***	0.589***
	(10.64)	(10.64)	(10.79)
Characteristics of schools and classes			
Established years		−0.001	−0.002
		(0.17)	(0.39)
Credential teachers (%)		−0.061	−0.101
		(0.24)	(0.40)
Male-female ratio		0.018	0.018
		(0.34)	(0.34)
Class size		−0.003	−0.005**
		(1.31)	(1.98)
Characteristics of head teachers			
Gender			0.008
			(0.18)
Age			−0.002
			(0.83)
Job title			0.231***
			(4.47)
Math teacher			0.054
			(1.15)
Constant	−0.020	0.191	0.118
	(0.07)	(0.58)	(0.35)
F -value	205.06***	134.21***	105.25***
R^2	0.505	0.506	0.516
Adjusted R^2	0.502	0.501	0.517
Obs.	1263	1263	1263

Note:***, ** and * represents the significance level at 1%, 5%, and 10%, respectively; the absolute t-value calculated using robust standard errors is reported in parentheses.

Table A5
First-step results of the 2SLS regression on the impact of a learning companion on a student's academic performance.

	The learning companion's SMG			
	a)	b)	c)	d)
IV_1:Education of a learning companion's mother	0.695***	0.689***	0.694***	0.603***
	(12.67)	(12.62)	(12.68)	(11.28)
IV_2:Education of a learning companion's father	0.795***	0.795***	0.789***	0.753***
	(16.59)	(16.63)	(16.48)	(15.31)
Characteristics of students and their families				
Age	−0.036	−0.033	−0.032	−0.021
	(1.62)	(1.52)	(1.44)	(0.99)
Gender	0.117***	0.128***	0.125***	0.156***
	(2.72)	(2.95)	(2.87)	(3.70)
Single child	−0.056	−0.062	−0.064	−0.047
	(0.95)	(1.04)	(1.09)	(0.75)
Hhsize	0.015	0.009	0.008	0.007
	(0.86)	(0.53)	(0.45)	(0.39)
Education of father	0.175***	0.180***	0.166***	0.097**
	(3.59)	(3.67)	(3.40)	(2.05)
Education of mother	0.089*	0.083*	0.081	0.005
	(1.78)	(1.67)	(0.45)	(0.10)
Characteristics of schools and classes				
Established years		0.002	0.002	
		(0.44)	(0.32)	
Credential teachers (%)		0.315	0.253	

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Table A5 (*continued*)

	The learning companion's SMG			
	a)	b)	c)	d)
		(1.25)	(1.19)	
Male-female ratio		−0.103*	−0.112*	
		(1.73)	(1.82)	
Class size		0.001	−0.001	
		(0.20)	(0.11)	
Characteristics of head teachers				
Gender			0.070	
			(1.42)	
Age			−0.003	
			(1.16)	
Job title			0.083*	
			(1.72)	
Math teacher			0.148***	
			(3.08)	
School fixed effects				Controlled
Constant	−0.631**	−0.577*	−0.508	−0.537*
	(2.39)	(1.84)	(1.61)	(1.95)
F-value	477.83***	466.16***	464.12***	363.21***
Centered R^2/ R^2	0.471	0.471	0.485	0.435
Un-centered R^2/ Adjusted R^2	0.471	0.472	0.486	0.439
Obs.	1263	1263	1263	1263

Note:***, ** and * represents the significance level at 1%, 5%, and 10%, respectively; the absolute t-value calculated using robust standard errors is reported in parentheses.

Table A6
Second-step results of the 2SLS regression on the impact of a learning companion on a student's academic performance.

	Individual's SMG			
	a)	b)	c)	d)
Peer effects				
The learning companion's SMG	0.161***	0.164***	0.164***	0.072*
	(4.89)	(4.83)	(4.88)	(1.93)
Characteristics of students and their families				
Age	−0.068***	−0.069***	−0.059**	−0.063***
	(2.84)	(2.88)	(2.49)	(2.65)
Gender	−0.040	−0.038	−0.039	0.001
	(0.94)	(0.87)	(0.90)	(0.03)
Single child	−0.100*	−0.100*	−0.107*	−0.092
	(1.74)	(1.69)	(1.82)	(1.50)
Hhsize	0.022	0.022	0.025	0.026
	(1.13)	(1.11)	(1.30)	(1.50)
Education of father	0.852***	0.853***	0.837***	0.799***
	(17.52)	(17.61)	(17.31)	(17.20)
Education of mother	0.634***	0.634***	0.633***	0.568***
	(11.32)	(11.31)	(11.47)	(10.84)
Characteristics of schools and classes				
Established years		−0.000	−0.001	
		(0.04)	(0.30)	
Credential teachers (%)		0.030	0.056	
		(0.12)	(0.22)	
Male-female ratio		0.014	0.018	
		(0.25)	(0.32)	
Class size		−0.002	−0.004	
		(0.73)	(1.62)	
Characteristics of head teachers				
Gender			0.005	
			(0.10)	
Age			−0.003	
			(1.31)	

(*continued on next page*)

Table A6 (*continued*)

	Individual's SMG			
	a)	b)	c)	d)
Job title			0.245***	
			(4.58)	
Math teacher			0.126***	
			(2.65)	
School fixed effects				Controlled
Constant	−0.031	0.085	0.062	−0.186
	(0.11)	(0.26)	(0.18)	(0.56)
Wald chi2	1206.07***	1226.49***	1343.26***	21.20***
R^2	0.471	0.466	0.479	0.549
Obs.	1263	1263	1263	1263

Note:***, ** and * represents the significance level at 1%, 5%, and 10%, respectively; the absolute t-value calculated using robust standard errors is reported in parentheses.

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