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# **BEST EVIDENCE** *of* **Chinese Education**

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**NEWSLETTER**

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## **Can Information Technology Promote the Development of Students' Cognitive Ability? Net Effect Estimation Based on CEPS**

*By Fang, C., Wang, G.X., Huang, B*

**T**HE influence of information technology on students' cognitive ability has become one of the research hotspots in the era of education informatization 2.0. Based on CEPS2014-2015 data provided by Renmin University of China, a recent study published in *Open Education Research* examines the net impact of information technology on students' cognitive development by adopting the PSM of quasi-experiment, in order to provide beneficial academic increment for students' research development.

The research indicates that:

- The benchmark regression shows that there is a positive correlation between the use of information technology and the development of students' cognitive ability, while the entertainment preference of the Internet shows an inverse relationship with the development of students' cognitive ability.
- The utilization of information technology at home is restricted by both effective demand and possible supply. Parents' increasing effective demand for Internet will boost the utilization of information technology at home, while the guidance and regulation of their children's Internet entertainment preference and the rise of their future educational expectations will inhibit the supply of family information technology.
- PSM reveals that the net impact of information technology on students' cognitive development falls into the range of [0.116, 0.126], the intervention effect of information technology on cognitive increment is an important thrust to reduce educational inequality.

In conclusion, in terms of family education, parents should control and restrict their children's use of the Internet in order to prevent teenagers from indulging in online games to restrain their cognitive development and affect their academic performance. Parents should also train their children to form Internet use plans and guide their children to change their preference for Internet use from entertainment to study. In the era of education informatization 2.0, investment of information infrastructure construction remains to be strengthened, especially in remote and poor areas. We should ensure the

physical access to the Internet and the effective supply of high-quality information resources in underdeveloped areas, and narrow the digital gap and educational inequality caused by the unbalanced distribution of educational resources in provinces. Schools should improve the use of the Internet, through multimedia, Mooc and other new means of teaching, so as to conduct the in-depth development of students' cognitive ability. At the same time, the family, school, government and society should build a multi-party linkage mechanism, and provide various forms of training for teachers to develop students' cognitive ability by using information technology.

*Source: Open Education Research, 2019; 25(4):100-110.*

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**NEWSLETTER**

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## **Can Educational Development Improve the National Innovation Capacity?**

*By Pu, X.S., Cao, P.J., Zhang, Y.J.*

**T**HE level of educational development is an important factor that affects national innovation ability. Recently, an empirical study published in the *Journal of Dalian University of Technology (Social Sciences)*, based on quantile regression model analyzed the relationship between global innovation index (including the innovation input, innovation output under the dimension of 82 indicators) and the level of educational development in 68 countries and regions in the world. Four dimensions of educational security, educational opportunities, educational quality and educational efficiency were analyzed of their impact on innovation ability in different countries; in order to reveal the impact of education on the innovation mechanism, accurately depict education development level, the innovation ability and the relationship between sustained economic growths.

Research findings are as follows:

- For the countries and regions ranging from medium low, medium, medium high to high level in the global innovation index, education has a significant positive effect on the improvement of national innovation capacity. Increasing the total score of education development level by one unit raises the national innovation index by about 0.30 to 0.37 units; In 2016, China's global innovation index was 50.57, far higher than the average of 39.14 and was standing at the middle and high position (that is, at the middle and high level of innovation ability). The overall level of education will play a greater role in the improvement of innovation ability.
- For the countries and regions ranging from medium low, medium, medium high to high level in the global innovation index, the educational security has an insignificant effect on the improvement of innovation ability, which indicated that educational security is a whole process. After surpassing certain level of educational security, it will exert an influence on the promotion of innovation. The effect of educational opportunity and educational quality on the different innovation indexes is not significant.
- For the countries and regions ranging from medium low, medium, medium high to high level in the global innovation index, education-

al efficiency score has a significant positive effect on the improvement of national innovation capacity. Every unit increase in the score of educational efficiency will lead to increase in the innovation index by 0.16 to 0.26 units, and the positive effect shows a gradually rising trend.

Recommendations:

- Education is the key support for the country's innovation capacity. To realize the strategy of innovation-driven development, it remains an urgent and long-term need to give priority to the development of education.
- Education security plays a role in promoting the improvement of innovation ability. We should not only invest more funds, but also increase the provision of teachers, increase the input of information technology, improve the basic supporting environment of education informatization, and comprehensively promote the deep integration of information technology and education and teaching.
- Educational opportunities, educational quality and educational efficiency have differentiated influences on the improvement of innovation ability. While ensuring the improvement of educational opportunities and internal quality of education, it is necessary to pay more attention to the improvement of external quality of education and constantly improve the ability to transform knowledge. Educational efficiency will play a greater role in promoting the improvement of innovation capacity and play a key supportive role in building a moderately prosperous society in all respects.

*Source: Journal of Dalian University of Technology (Soc Sci), 2019; 40(4):104-109.*

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## **Does Closed-End Management Promote the Development of Secondary Vocational School Students?**

*By Li, G.R., Xu, J.J., Cui, Y.K.*

A STUDY published in *Education Development Research*, based on the follow-up data of a survey on students in 43 closed secondary vocational schools and 29 non-closed secondary vocational schools, used a multiple linear regression model to explore the effects of closed-end management on students' academic performance and their employment status after graduation. The results show that:

- Closed-end management has no significant educational advantages in secondary vocational schools. Closed-end management increases the school time of secondary vocational students, but it has neither significant advantages in improving students' academic and professional performances, nor in improving students' psychological health, self-acknowledgement of knowledge and skills acquisition, behavior in schools and the decrease in dropout rate. According to the graduates' employment, closed-end management increases higher education attainment; however, it has reduced the initial salary and satisfaction with the job, and there is no significant impact on relevance with their major, career development and job stability.
- The research shows that although closed schools have the form of "closed", the closed-managed school administration system still lacks effective management mechanism. Closed-end management increases the temporal costs that secondary vocational students study in school and reduces the time that students use electronic products such as phones and computers, but schools do not provide scientific guidance on how to manage it. At the same time, closed-end management increases the cost in communication between teachers and students, but it does not have significant effect on the improvement of the relationship between teachers and students and on the improvement of students' bad behavior.

Therefore, the research believes that closed-end management is not the key to improving the quality of secondary vocational education. The crucial point of management innovation is not mode innovation but educating students. From management to governance, and from discipline to promotion, effectively guiding students to be self-conscious and self-disciplined is the key.

*Source: Education Development Research, 2019; 39(11):59-65.*

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## **The Current Status of Parental Involvement and Its Influence on Preschool Children's Readiness for Elementary Schools**

*By Li, Y., Jia, M.Q., Zheng, W.T., Tang, L., Bai, Y.*

A STUDY published in *Journal of East China Normal University (Educational Sciences)* focuses on the early development of Chinese children's understanding. Based on the survey data of poor rural areas in China, the status quo and influencing factors of early childhood cognitive development in China's economically underdeveloped areas are analyzed by using the method of descriptive statistical analysis and multiple linear regression analysis.

The results show that:

- In poor rural areas of China, the proportion of children with delayed cognitive development risk is as high as 40%, but there is a significant urban-rural difference, with urban children tending to show higher levels of cognitive development (The proportion of children showing developmental delays is 25.53% in urban areas and 43.78% in rural areas).
- In the poverty areas of western China, the level of parenting knowledge is generally not high. The overall parenting behavior of dependents is poor, and the parent-child interaction is less. The parenting behavior of dependents also shows obvious urban-rural differences. The parenting behavior is significantly better than the rural areas in terms of "quantity"; the higher education level of mothers in urban areas can ensure that the "quality" of parenting behavior may be better than that in rural areas.
- Parenting behavior and parenting knowledge of dependents are closely related to the level of infants' cognitive development. However, when controlling for Hukou type, the relationship between parenting behavior and cognitive development becomes insignificant, which may be the result of the difference in the "quantity" and "quality" of parenting behavior between urban and rural areas.

The author points out that the Chinese government should not only strengthen and improve public policies and service systems for the development of children aged 0-3, but also invest in education and parenting training to ensure that family members pay more attention to cultivating awareness,

knowledge, and good behavior in their children, so as to effectively improve the status of children's early cognitive development in rural areas.

*Source: Journal of East China Normal University (Edu Sci), 2019; 37(03):17-32.*

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NEWSLETTER

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## **Does Farmers' Loss of Farmland Affect Their Children's Academic Performance?**

*By Liu, J.K., He, G.Y.*

**W**ITH the rapid expansion of urban space and the rapid growth of land revenues, the number of landless peasants has increased dramatically, and disputes and conflicts over land interests have become an important source of social stability. Using data from China Family Panel Studies (CFPS 2010), a recent analysis published in *Education Research* discusses the influence of farmers' loss of farmland on their children's academic performance and its mechanism. within the framework of life history theory. The research results show that:

- Compared to rural families who have not experienced land acquisition, the children of land-losing families have significantly lower Chinese scores and summation scores in Chinese and math.
- Land-losing families have less education expenditures for their children than non-lost families, and parents of land-losing families are also less demanding in terms of parenting style than non-lost families.
- Education expenditure and demanding education style are the mediating mechanism of losing land to reduce adolescents' academic performance, but the effect of demanding education style is stronger.
- For land-losing families, obtaining new jobs can reduce the negative impact of losing land on the Chinese performance of adolescents, and even make the total scores of children who have lost their land higher than those who have not lost.
- There is a gender difference in the negative effects of peasants' losing land on their children's academic performance. The specific difference is that the gap in academic performance between children who have lost their land and those who have not is particularly prominent among boys.

*Source: Educational Research, 2019; 8:115-126.*



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NEWSLETTER

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## **Paper Books, Computers and Kindle, Which Do Junior School Freshmen Prefer?**

*By Dai, B.Y., Deng, L., Jian, X.Z., Wang, D.D., Wang, Y.J.*

**I**N recent years, with the popularity of mobile devices, more and more children are reading on computers and electronic reading devices like the Kindle. So, which is more popular among children: traditional paper books, computers or Kindles?

An article published in *Psychological Exploration* answers this question. The research team uses the Cognitive Load Scale and the Attitude Preference Questionnaire to explore the differences in the cognitive load (the amount of thinking required for a student to complete a learning task) and attitude preference (preference for paper, computers and e-readers) of junior school freshmen based on different information carriers (paper, computers, e-readers), using the same article as the material. The article draws the following conclusions.

- Compared with computers and e-readers, students need more time to understand and process the information in paper reading.
- Junior school freshmen are more willing to read on computers.
- Students prefer to choose information carriers that make them easy to remember and absorb the content.

Based on the above conclusions, the research team recommends: When teaching a long article, teachers can allow students to use e-reading mode; when the article is relatively short, teachers can use paper-reading.

*Source: Psychology Exploration, 2019; (4):363-367.*

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**NEWSLETTER**

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## **What is the Effectiveness of Education in Poverty Alleviation?**

*By Peng, N.Y.*

**P**OVERTY alleviation through education refers to the process of increasing income and getting rid of poverty through education investment. In order to achieve an all-round well-off society and implement Jinping Xi's strategy of poverty alleviation through education, education finance at all levels has increased investment in poverty alleviation through education in recent years, striving to reach the goal of poverty alleviation by 2020.

Using the provincial mixed panel data consisting of regional annual data from 2002 to 2016 published on the website of the National Bureau of Statistics as the research data, a recent empirical study published in *Tsinghua Journal of Education* took 22 provincial-level administrative regions where poor areas are located, seven provincial-level administrative regions where severely poor areas are located, and the locations of deeply poor areas as the research samples, and carried out cluster analysis for 31 provinces (municipalities directly under the central government and autonomous regions) in China according to the data of farmers' net income, which is divided into low, middle and high income areas (as a control group). The most widely used Cobb-Douglas production function construction model was used to study the impact of five factors (education input, production development, relocation, ecological compensation and social security) and farmers' per capita income, so as to evaluate the effect of poverty alleviation through education.

Research finding are as follows:

- Education input is the only positive factor that has a stable effect on farmers' income, and its poverty alleviation effect is higher than other factors (due to some reasons, other factors are either positive or negative and not stable), which can stimulate the increase of farmers' income.
- Significant progress has been made in poverty alleviation through education. For every 1% increase in education input in poor areas, the net income of rural residents increases by more than 1%, especially in the "three districts and three prefectures" (Tibet, Xinjiang, Qinghai, Sichuan, Yunnan, Gansu) (1.83% increase, while there is only 0.24% increase in higher-income areas over the same period. It can be seen that the same investment in education has a greater im-

pact on lower income areas and is more efficient. It also shows that lower income areas are more dependent on education investment than higher income areas. In other words, once the growth rate slows down, the growth rate of per capita income will slow down to a greater extent than that of higher income areas.

- The effectiveness of poverty alleviation through education needs the joint efforts of various parties. However, the investment in education should not be separated from the economic environment. It needs to match the level of local economic development to make local finance “affordable”.

Policy recommendations based on the effectiveness of education in poverty alleviation:

- We study the effectiveness of poverty alleviation through education, not only to supervise and manage the past investment in education, but also to give prediction and suggestions on the path of future investment path. However, in this process, due to the difference in data sources, the research is also relatively insufficient. Therefore, the scientific rationality of relevant data should be paid attention to.
- Education input is divided into material capital input (hardware facilities) and human capital input (human quality and ability input). Schultz pointed out that human capital is the main cause of economic growth, which plays a fundamental, dominant and long-term role and can bring about regional economic growth and increase of personal income with a high rate of return. Therefore, with human capital investment as our main focus, we must increase investment in education, establish a funding system that matches the scale of running schools at all levels and of all kinds, ensure that education funding is fully implemented, give priority to the development of education, improve the level of compulsory education, accelerate the development of vocational education and guide social support.
- The investment of education funds should be inclined to poor areas, and the system and mechanism for the investment and management of education funds should be established to give full play to the advantages of poverty alleviation through education.
- Establish a long-term education investment mechanism that aims to eliminate poverty and prevent poverty. First, correct ideological understanding, enhance poverty alleviation initiative, and improve the endogenous power; The second is to improve the intelligence structure, supplement the short board of knowledge, and increase income-generating skills. We should combine macro with micro, integrate all aspects with key points, combine economic support with development, and combine short-term goals with long-term goals.

*Source: Tsinghua Journal of Education, 2019; 40(4):90-97.*

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NEWSLETTER

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## Is Boarding Education Good for Children's Development?

By Zhu, Z.S., Li, Y.N., Song, Y.Q.

At present, the rural boarding school is regarded as the best alternative to solve the problem of lack of family education for rural children, especially left-behind children. However, it is still debatable whether its educational function can be brought into full play. A study published in *Education Research*, focusing on the impacts of boarding education on children's cognitive and non-cognitive abilities, tracks fourth and fifth graders students from 137 boarding schools in poverty-stricken rural areas in five counties of Hebei and Sichuan Provinces over a three-year period. This study adopts stratified cluster random sampling method, takes children's boarding state (boarding age and boarding duration) as the core independent variable, measures children's cognitive ability with reading performance, children's non-cognitive ability with self-esteem, depression and stress resistance, and establishes a regression model for empirical research.

Research findings are as follows:

- From the external perspective of boarding children, the cognitive ability of boarding children is significantly lower than that of non-boarding children. Their reading scores are relatively low and they are less likely to enter the middle and upper ranks of the grade. Boarding children also have poor scores for depression, self-esteem and stress tolerance, and are at higher risk of depression.
- From the internal perspective of boarding children, both cognitive and non-cognitive abilities of young boarding children are weaker than those of school-age boarding children, and with the extension of boarding time, their cognitive and non-cognitive abilities develop worse.
- From the perspective of both parents, the impact of boarding on unleft-behind children is significantly lower than that of children with both or one parents out, and the family substitution function of rural boarding education has not been effectively played.
- From the point of family environment, the negative impact of boarding on rural children's development has obvious phenomenon of "elite capture", which is manifested by the fact that boarding has a greater negative impact on rural boys, rural children from better-off

family, rural children whose mothers are better educated and those in areas with relatively good level of economic development, which is bound to widen the polarization among rural children.

It can be seen that the education boarding system in the poverty-stricken rural areas of China is not conducive to the formation and accumulation of rural children's human capital on the whole at present, and it has a negative impact on the cognitive and non-cognitive abilities of rural children.

Therefore, the author puts forward three measures to solve the dilemma of rural boarding schools:

- Expanding financial input in education: We will take into overall consideration the differences between boarding schools and non-boarding schools, strengthen the standardization construction of boarding schools, and give proper preference to financial investment and subsidies in order to improve school conditions.
- Strengthening the development of teaching staffs: Increasing the proportion of public teachers will have an adverse effect. On the contrary, increasing the number of per-student teachers is the most effective way to alleviate the negative impact of boarding education, which is especially important for increasing the positive effect on non-cognition of children.
- Increasing household investment: Frequent communication between parents and children can effectively reduce the risk of depression in boarding children, and this kind of children's self-esteem and resistance levels are not significantly different from those of non-boarding children.

We should re-examine the effect of rural boarding school education, and carry out a reasonable policy mix design on the implementation of the dual strategy of rejuvenating China through science and education and rural revitalization. In addition to creating an educational environment and strengthening the construction of teaching staff, it is also necessary to build a "home-school-society" linkage training mechanism and education support system, in which the government takes the back, schools are the main body, parents are the main responsibility and the society participates. Only through policy synergy can we effectively break through the dilemma.

*Source: Education Research, 2019; 475(8):79-91.*

# The Impact of School Resource Investment on Student Performance: A Meta-analysis Based on Chinese Literature

Yahui Tian, Jijun Yao

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**Abstract.** Using meta-analysis, this study analyzes a total of 20 effects on 11 articles on the impact of Chinese school resource investment on student performance. We found that: 1) the overall impact of school resources on student performance is significant (effect amount is 0.093,  $p = 0.001$ ); 2) compared with the effect of school human resources investment and financial resources investment, human resources are superior, the effect amounts are 0.121 ( $p < 0.01$ ), 0.120 ( $p = 0.014$ ); the effect of material resource is the lowest, but the impact is also very important with an effect amount of 0.099 ( $p = 0.009$ ); 3) in human resource investment, teacher experience, teacher education, teacher qualifications, teacher training, teacher titles, and student-teacher ratios all have a positive and significant impact on student performance. Among the material resources, computer networking rates, average student fixed assets, average classroom and school areas affect students' achievements significantly; 4) from a disciplinary perspective, the impact of school resource investment on Chinese language and mathematics is more significant, and from a regional perspective, the impact on central and western regions is more significant. We suggest based on our findings as: First, increase investment in school resources, especially financial resources and investment in schools in the western region; Second, pay attention to the input and allocation of teachers' resources, especially to improve the shortage of small-scale high-quality teachers in rural areas; Third, keep pace with the times and improve the allocation of physical conditions in schools.

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**Keywords:** Meta-Analysis; School Resource investment; Student Performance

## Question

THE findings of the Coleman Report show that school resource investment does not have a significant impact on student performance (Coleman, et al., 1966). This finding has sparked a lot of research and debate about the relationship between school resources and student achievement. Since then, the use of educational production functions to study the relationship between school resources and student performance has become a hot topic in related fields. But until today, no consensus has been reached on such studies. Two of the most representative views are the related arguments of Hanushek and Hedges. Hanushek's series of studies have not found direct evidence that school resource investment significantly affects student achievement, and therefore believes that education policy cannot be simply thought of when it comes to school resource investment (Hanushek, 1989; Hanushek, 1995; Hanushek, 1997). But Hedges and others have criticized and questioned Hanushek's research methods, research data, and research results. They used meta-analysis to re-analyze the data used by Hanushek in 1989, and obtained the opposite of Hanushek's conclusion. The meta-analysis results show that most of the school's resources have a significant impact on student performance, including the average student expenditure; teachers' quality (teacher education, experience, and ability) has a positive and significant positive impact on student performance, while school size and class size have significant negative correlations with student performance (Hedges, et al., 1994). A series of research by Hedges et al. has re-ignited people's emphasis on school resource investment. However, due to the complexity of the relationship between school investment and student achievement, a large number of subsequent studies have also found that: due to the country's sentiment, research data, relevant research conclusions are not completely consistent for reasons such as the setting of the model and the selection of variables. For example, Fuller analyzed the relationship between school resources and student performance in the Third World, and found that in developing countries, school factors are the main cause of differences in student performance (Fuller, 1987). Hattie used meta-analysis to analyze more than 800 factors affecting student academic achievement, including comprehensive analysis of six types of factors: individual students, families, schools, teachers, courses and teaching, and found that school resources have a positive and significant impact on student performance. Among them, the influence of teachers is the most significant and has been hailed as the "Holy Grail of Teaching" by Hattie (Hattie, 2015).

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**Conflict of Interests:** None.

Research from China on the relationship between school resource investment and student performance started late. At the end of the 1990s, Jiang (2000) studied the rural bases through multivariate analysis of variance and related analysis, using statistics on education expenditure and education in 328 counties in nine provinces of East, Central and West China in 1990. The relationship between education investment and student achievement (Jiang, 2000). This study opened the prelude to China's research on school resources and student performance. Especially since 2006, more and more related studies have been conducted, but so far, no uniform conclusion has been reached. Some scholars have found that school resources, such as teacher age, student-teacher ratio, average number of students, average school area, average classroom area, average student education expenses, average student career expenses, and average student public expenses, etc., have significant effects on student performance (Hu, 2007), but some scholars have found that some indicators have little or no correlation with student performance. For example, Zhao found that the average teaching age of teachers will negatively affect student performance (Zhao, 2013).

It can be seen that in the past 5 decades, there has been an endless stream of research on school resources and student performance, but so far, relevant research has not yet reached a clear and consistent conclusion. However, such studies have found that there are some correlations between school resources and student performance, and this relationship mainly exists in the three areas of human, finance, and material. Compared with foreign studies, because Chinese school-related data is more difficult to obtain, there are fewer empirical studies on the relationship between school resources and student performance. The reason did not reach a consensus conclusion. This leads to the lack of the best evidence of robustness in improving the process and efficiency of school resource investment, which affects the scientificity and pertinence of decision-making. Considering that China is a large and rapidly developing country, synthesizing the evidence on the relationship between Chinese school resource investment and school output will help us understand the relationship between the two in a more detailed and comprehensive manner, and it will also help us Provide "best evidence" from China for theoretical research in this area. Such research can not only have a more accurate understanding of the benefits of human, financial, and material inputs, but also have important reference values for improving future education finances, school-level education resource allocation, and funding input. Because the conclusions of the existing empirical studies are not consistent, the most suitable analysis methods in this process are meta-analysis and systematic evaluation. But so far, the meta-analysis or systematic review of China in this field is almost blank. Therefore, no matter from the theoretical research or policy improvement, it is urgent to give solid evidence for the following issues: (1) What is the relationship between school resource investment and student achievement? (2) Which of the human, material and financial resources of school resources has a greater impact on student performance?

## **Definition**

## **School Resources**

School resources refer to the sum of resources occupied, used and consumed to maintain school education and teaching activities. School resources are usually divided into three dimensions: human, material and financial resources. Specifically, the school's human resources, that is, the school teacher team and students, of which the teacher team includes full-time teachers and non-full-time teachers, this study mainly discusses the impact of full-time teachers on student performance. Material resources refer to tangible assets and low-value consumables invested in schools, such as school buildings, land, books, materials, and other fixed assets. Financial resources usually refer to the monetary performance of human and material resources (Hanushek, 1997).

In the selection of indicators of various dimensions, we draw on the practice of scholars at home and abroad. Teacher qualification, teacher education, teacher teaching age, teacher training, teacher-student ratio and teacher title were selected as the indicators of school human resources input. The average school area of the students, the average number of school books, the average classroom area of the students, the average building area of the students 'school, the average number of students' computers, and the computer network rate are taken as the indicators of the school's material resources. The average public funding of students is used as an indicator of the financial resources of the school (see **Table 1** for the meaning of each indicator).

## **Academic Performance**

Students' academic performance is the primary concern of parents and an important indicator for measuring the effectiveness of school education (Li & Zhang, 2018). It also predicts the level of education that students may receive in the future and the benefits in the labor market (Lipsey & Wilson, 2001). This article measures the impact of school resource investment on student performance, including both the student's overall academic performance and various subjects (such as mathematics, Chinese language, English, science, etc.).

## **Research Design**

### **Analysis Methods and Tools**

The analysis method used in this study is meta-analysis, which is a literature analysis method combining qualitative and quantitative analysis methods (Xia, 2005), that is, a method of statistical analysis of a single research result by synthesizing existing related research findings (Gu & Hu, 2018; Glass, 1976). Unlike traditional literature analysis, it extracts relevant information from existing research, such as sample size, standard deviation, correlation coefficient, etc., calculates the effect amount, and judges the degree and direction of the impact based on the size and direction of the effect amount. This avoids the subjectivity and non-repeatability of traditional literature analysis and helps people to obtain "best evidence" (Gu & Hu, 2018).

The effect size refers to the comparison between different studies by standardizing the results of each study. Different types of meta-analysis have different effect sizes (Lipsey & Wilson, 2001). There are two types of commonly used effect quantities. One is the standard difference type, such as Cohen's *d*, Hedges' *g*, and Glass *A* (Lu, et al., 2011). Because most of the current meta-analysis are based on experimental studies to investigate the effect of an experimental intervention on the experimental results, *d* or *g* are mostly used for the effect amount. The other is the correlation effect, which mainly includes  $r_{\text{pearson}}$  and  $r_{\text{pb}}$  (Ferguson, 2009). Most of this type of effect is suitable for univariate correlation analysis and analysis of variance. As the research on the relationship between school resource investment and student performance is mostly based on multiple regression analysis or multi-level linear models, these types of effect quantities are not applicable. For this reason, in many such studies, standardized regression coefficients are used as the effect size (Mark et al., 2001). When Hedges et al. analyzed the impact of school resource investment on student performance, considering that in all studies, input variables and output variables are usually not measured on the same scale, the partial regression coefficients obtained cannot be directly calculated or compared. Therefore, standard regression coefficients are used as effect quantities for combination and comparison (Greenwald et al., 1996). The standard regression coefficient measures the change in the output variable caused by a standard deviation change in the input variable.

Since not all studies have reported standardized regression coefficients. Therefore, in the following research, we first refer to the calculation formula of Nieminen et al. (Nieminen et al., 2013) to convert the non-standardized regression coefficients into standardized coefficients; then use Comprehensive Meta Analysis 2.0 (CMA 2.0) software developed by Biostat to calculate the effect amount Test heterogeneity, perform sensitivity analysis, and test for publication bias. In addition, in specific calculations, in order to ensure the principle of sample independence, using documents as the unit, first calculate the overall effect amount of each document and the corresponding effect amount of human, material and financial resources; then combine the overall effect amounts of all documents, manpower input effect amount, material input effect amount, and financial input effect amount.

## Collection and Selection

First, determine the inclusion criteria for the literature. The inclusion criteria need to be accurately framed, including the type of document, year, language, research method used, and whether the effect size can be calculated. The rest depends on the specific research purpose. This process should be avoided as much as possible based on the personal preference of the researcher, and its criteria need to be determined more based on the research purpose, research content, literature characteristics and statistical requirements. The criteria for document inclusion need to include at least the following basic elements: the salient features of the document to be included, the research object, the key variables, the study design, the cultural and linguistic range, the time range, and the

type of document. Based on the research purpose and the basic elements that the inclusion criteria should include, this study has developed six criteria to screen the literature:

1. The study was published between 1990 and 2018. The language used is Chinese and/or English, and the type of literature is not limited.
2. The research content is the impact of school running conditions on the academic performance of basic education students. The school running conditions include human, material and financial resources or one of them.
3. The research objects only include research from ordinary middle and elementary schools in China, excluding pre-school education, vocational education, and higher education.
4. The research must present clear, clear and complete statistical data results. Statistical information such as the mean, standard deviation, sample size or t value, F value should be reported to ensure that the effect amount can be calculated.
5. Research methods are limited to empirical research. Including (quasi) experimental research and research based on experimental research ideas (such as research using RDD, DID, PSM methods), and research using multilayer linear model (HLM), structural equations, correlation analysis and other methods.
6. The dependent variable of the research model is the student's academic performance, including the total score and the results of various subjects such as Chinese language, mathematics, and English.

Secondly, the literature was searched according to the criteria. The keywords we searched are "school resources", "school conditions", "academic performance", "academic performance", "academic achievements", "teacher resources", "teacher human capital", "school investment", "Financial investment in education", "education production function", etc. The search database includes educational databases such as CNKI, CQVIP, Wanfang Data, Baidu Academic, Google Academic Mirror, EBSCOhost, JSTOR Retrospective Database, etc., and obtained more relevant literature through the "snowball" method. A total of 161,897 articles were retrieved through keyword searches. By contrasting with the inclusion criteria, first of all, screening is performed according to the title of the document to exclude studies that do not meet the requirements. After screening based on the keywords, the title and abstract of the article are read to further exclude the research that does not meet the requirements. Finally, the remaining documents are read in full. A total of 11 studies were included, including 20 effect sizes. The details of the literature search in each database are as follows (**Figure 1**).

## **Extract and Encode Bibliographic Information**

The information included in the extracted literature includes author, publication year, research grade, research area, data type, research method, independent variable selection, dependent variable selection, sample information (including sample size, and demographic characteristics of the sample) and average, T value, standard deviation and

<b>Table 1. The Meaning of Each Indicator.</b>	
<b>School Resources</b>	<b>Indicator Variables and Meanings</b>
Human Resources	Teacher qualification: whether there is a teacher qualification certificate, the proportion of teachers qualification certificate
	Teacher age: that is, using the number of years of teaching as a proxy for teacher experience
	Teacher's education: the education level of the teacher
	Teacher training: the total training time for teachers
	Teacher-student ratio: number of full-time teachers / number of students
Material Resources	Teacher titles: namely junior titles, intermediate titles, senior titles
	Students are school area; the ratio of the number of students and the school covers
	Students are school drawing book ratio of the number of copies :: books and school books count the number of students
	Classroom area per student: Ratio of school classroom area to student population
	School building area per student: Ratio of school building area to student number
	Number of computers per student: Ratio of computers to students in schools
Financial Resources	Computer networking rate: ratio of the number of computers connected to the school to the total number of computers owned by the school
	Public Funds per student: Ratio of public funds to number of students

other information to calculate the effect amount. The encoding rules used are as follows (Table 2).

1. Input Variable: In human resources, the student-teacher ratio is coded as P/T; the teacher-student ratio is coded as T/P; the teacher qualification code is TEq; the teacher experience code is TExp; the teacher education code is Ted; the teacher the title code is TEt, and the teacher training code is TEc. In material resources, the number of students per book is coded as PSB; the number of students per computer is coded as PSC; the computer network rate is coded as RC; the number of students per year of fixed assets is coded as PCFA; the average construction area per student is GFPS. Among the financial resources, the public expenditure code per student is PPE.
2. Output Variable: The total score is coded as Total, the math score is coded as Math, the language score is coded as Chinese, the language reading score is Reading, the English score is coded as English, the science score is coded as Science, and other scores are coded as U.
3. Grade: Elementary school code is P, middle school code is S, and high school code is H.

**Table 2. Document Coding.**

#	Author	IV	OV	RS	SA	SS	RD	LT	DT
1	Liang Huang (2018)	PSC, RC, TEq, Ted	Math, Reading, Science	S	E	HLM	FL	J	G
2	Xiangyun Li, Ping Wei (2014)	T/P, TEt, PSB, PCFA, PPE	Chinese, Math	P	M	HLM	FL	J	I
3	Xue Xia (2009)	TEt	Math	P	W	HLM	FL	non-J	C
4	Yuhong Du, Yongmei Hu (2009)	PSB, SAFA, TEq, P/T, TExp, PPE	Chinese, Math	S	W	OLS	QL	J	C
5	Haiping Xue, Weifang Min (2008)	PPE, Ted, TEq, TEt, TEc, TExp	Chinese, Math	S	EM	HLM	QL	J	C
6	Yongmei Hu (2007)	PSCA, PSB, SAFA, P/T, TEq, PPE	Chinese, Math	P, S	W	HLM	QL	non-J	C
7	Xuehui An, Emily Hannum, Tanja Sargent (2008)	TExp, Ted	Total	P	N	HLM	QL	J	C
8	Jennifer Adams (2012)	TExp, TEt, Ted	Math	P	W	HLM	FL	J	C
9	Qiuyi Weng (2009)	SAFA, GFPS,	Total	S	EW	OLS	FL	J	C
10	Yanqing Ding, Haiping Xue (2008)	PPE, Ted, TEq, T/P	Total	H	W	HLM	QL	J	C
11	Haiping Xue, Rong Wang (2009)	PPE, Ted, TEq, TEt, TEc, TExp, P/T	Math	P, S	EM	HLM	QL	J	C

Note: IV: Input Variable; OV: Output Variable; RS: Research Section; SA: Study Area; SS: Sample Size; RD: Research Design; LT: Literature Type; DT: Data Type.

4. Study Area (Area): the national code is N, the eastern code is E, the central code is M, the western code is W, the eastern and central and central and eastern codes are both EM, and the central and western and central and western codes are MW.
5. Method: The multivariate linear model is OLS, and the multilayer linear model is HLM.
6. Study Design: With reference to the practice of Greenwald et al., The research design is divided into longitudinal studies (coded as L) and quasi-longitudinal studies (coded as L) according to whether the study includes front-to-back testing, whether to control student IQ, and previous performance. Coded as QL and Non-Longitudinal Studies (FL). In this sample, only quasi-longitudinal and non-longitudinal studies are included.
7. Literature Type (Lt): Articles published in journals are coded as J, and non-journal literatures are coded as non-J.
8. Data Sources: According to the data sources, the data is divided into three categories: first, international data, such as PISA, authoritative data with global significance, coded as G; followed by some important issues in

China There are semi-official and authoritative data in China. Such data is usually large-scale survey data of multi-agency cooperation across provinces. The measurement tools used by them are authoritative institutions or experts to develop standardized test papers. The relevant questionnaires have also been repeatedly verified and coded as C; once again, the data obtained by researchers and their research groups through self-made questionnaires, and the reliability and representativeness of the results Sex is worse than the former two, coded as I.

In many previous meta-analysis studies, the sample size, randomness of sampling, etc. are often coded and discussed. However, in our research, all samples are large samples, and the sampling methods are generally consistent, so we did not separately encode and analyze such information.

## **Analysis Framework**

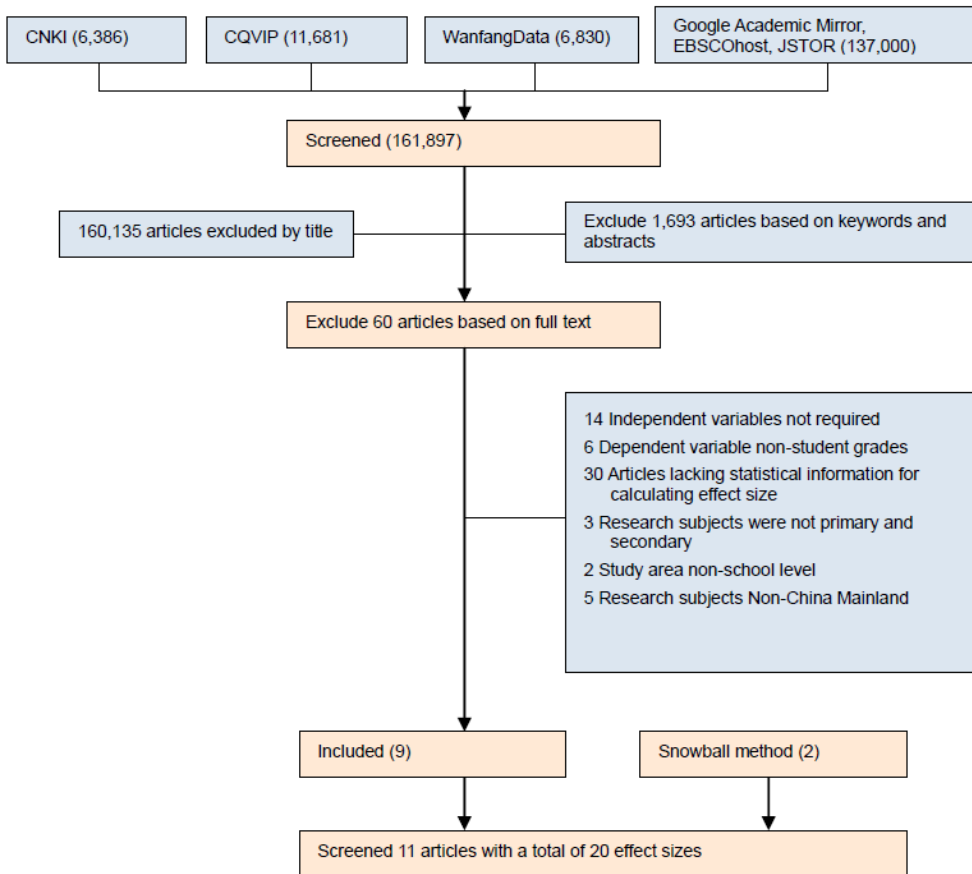
We first analyzed the overall impact of school resources on student performance, and then separately analyzed the impact of student human resources, material resources and financial resources on student performance, thereby determining which aspects of investment are more effective. On this basis, we further analyzed the impact of human resources and material resources on student performance. Student grades include student grades and total student grades. At the same time, the introduction of moderating variables, that is, the impact of different disciplines, different academic periods, different research areas, different research methods, different research designs, literature types and data types on student performance, in order to test the sources of heterogeneity between different studies, and then comprehensively evaluate The impact of school resource investment on student performance (see **Figure 2** for the analysis framework). According to the steps of the meta-analysis, the quality of the included literature should be evaluated. However, in most cases, such quality evaluation standards are mainly applicable to the literature of experimental research, from whether the experimental design and process of the included literature are scientifically and rationally evaluated (Valentine & Cooper, 2003). Such criteria are not suitable for this study. Because the documents we included are all officially published academic papers, which have undergone strict peer review, the research process is rigorous, and the conclusions are robust and reliable, the included documents have high quality and can meet the requirements of meta-analysis.

## **Results**

### **Heterogeneity Test and Model Selection**

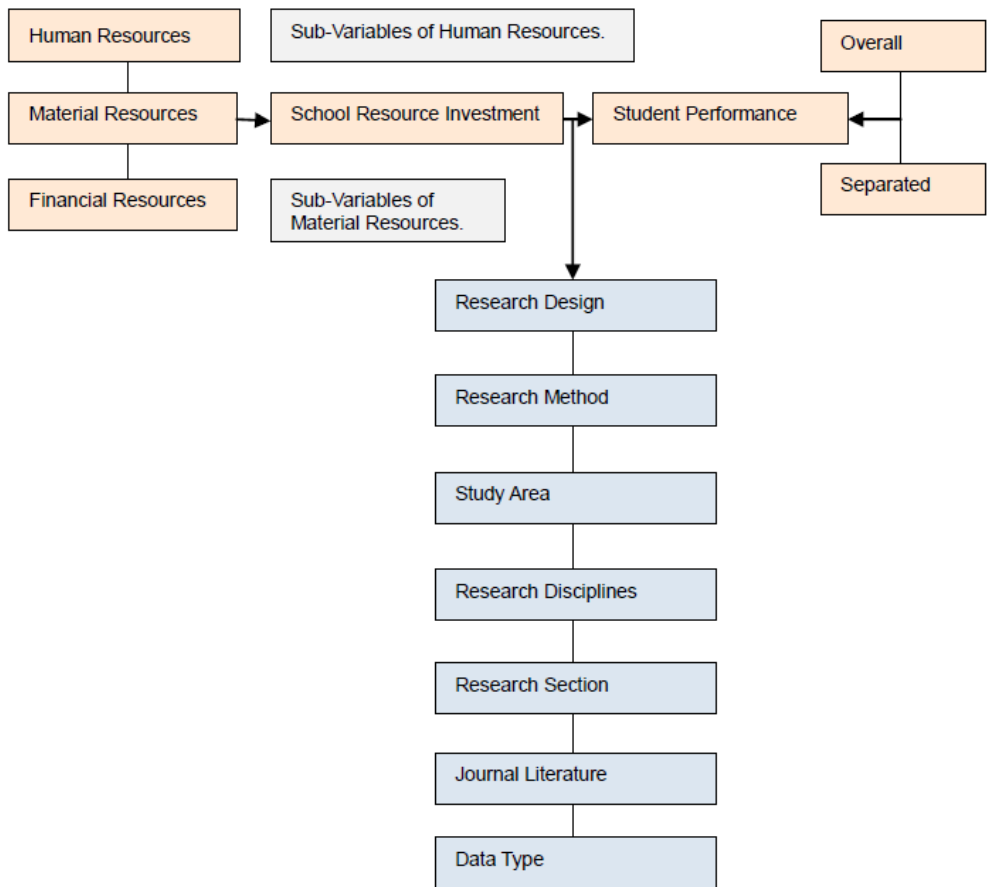
In order to accurately examine the impact of school resource investment on student performance, a heterogeneity test was first performed. Tests for heterogeneity refer to whether different studies have heterogeneity and what causes heterogeneity. It is also called tests for homogeneity or homogeneity test. With reference to the results of heter-

**Figure 1. Database Retrieval Flowchart.**



ogeneity analysis, a suitable statistical model is selected (Rücker, et al., 2008; Xia, 2005). If the test result is not significant ( $p > 0.05$ ), it indicates that the studies are homogeneous, and a fixed effect model is selected; if the test result is significant ( $p < 0.05$ ), it indicates that there is heterogeneity between different studies. If there is heterogeneity, there are usually two processing methods. One is to use subgroup analysis and sensitivity analysis to eliminate heterogeneity processing methods such as extreme values or statistics with opposite directions, and then make it homogeneous using a fixed effects model (Xia, 2005); another method is to use a random effects model. However, Borenstein et al. proposed that the choice of analysis model should also be based on the source of heterogeneity. If the heterogeneity originates only from sampling errors, a fixed-effect model is selected. If it is assumed that in addition to sampling errors, heterogeneity also comes from factors such as study design and sample characteristics, a random effect model is selected (Borenstein, et al., 2009).

**Figure 2. Analysis Framework Diagram.**



In the heterogeneity test of the overall impact of school resource investment on student performance,  $Q = 674.236$  ( $p < 0.001$ ) indicates that there is heterogeneity between the samples, and  $I^2 = 97.182$ , indicating that about 97% of the variation comes from the difference between the effect values. Only 3% of the variation was due to sampling errors, so a random effects model was used for analysis. The test of the heterogeneity of the impact of school human, material and financial resources on student performance also shows that there are differences between different studies, and the variation mainly comes from factors other than errors, so a random effect model is also adopted.

## **The Overall Impact of School Resource investment on Student Performance**

In the analysis of the results, referring to the practice of Greenwald et al., The effect size (**Table 3**) obtained was analyzed according to the standard regression coefficient, and the influence of this variable on student performance was analyzed (2009). The overall impact of school resource investment on student performance is shown in **Table 4**. The effect amount  $ES = 0.093$  ( $p = 0.001$ ), which is equivalent to a standard regression coefficient of 0.093. That is, an increase of one standard deviation in school resource investment will increase student performance by 0.093 of the standard deviation. This effect is very significant. Increasing investment in school resources will have a large impact on student performance, a result that is consistent with the conclusions of Hedges et al. (1994) and Hattie (2015).

## The Impact of School Personnel, Finance, and Material Inputs on Student Performance

According to the results in **Table 4**, it can be seen that the input of school human resources has the greatest impact on student performance, with an effect amount of 0.121 ( $p < 0.001$ ), that is, an increase of one standard deviation in school human resource investment will increase student performance by 0.121 standard deviation, which is quite large Impact. The impact of financial resources investment is equivalent to that of human resources, with an effect size of 0.120 ( $p = 0.014$ ). The last is the impact of the school's material resource investment, with an effect amount of 0.099 ( $p = 0.009$ ), which is less than the impact of financial and human resources, but it is sufficient to have an important impact on student performance.

Use subgroup analysis to explore the impact of human resource variables on student performance (see **Table 5** for results). Since the teacher-student ratio and the student-teacher ratio are inverse relations to each other and cannot be simply merged, referring to the practice of Hedges et al., The effect magnitudes of the teacher-student ratio and the student-teacher ratio are calculated separately. The results in **Table 5** show that in human resources, teacher experience, teacher training, teacher education, teacher titles, teacher qualifications, and student-teacher ratio all significantly affect student performance, and the effect range is [0.101, 0.185]. The results of this study are consistent with Hedges' report (Hedges, et al., 1994). However, the results show that the teacher-student ratio has no significant effect on student performance. This result may be because only three teachers-student ratios were used in the collected samples, so this result needs to be treated with caution.

Similar to human resources, subgroup analysis of the input effect of each variable of material resources was used (**Table 6**). However, unlike the results of various human resources variables, among the material resources, only the computer networking rate, the average fixed assets per student, the classroom area per student, and the school area per student significantly affect student performance and the effect range is [0.032, 0.222], but the number of students per computer, building area per student, and number of books per student did not significantly affect student performance. However, it should also be noted that the sample size of each variable in the material resources is

**Table 3. Effect Amount Report.**

#	Author	Output Variable	Effect Size			
			Overall	Human Resources	e-Material Resources	Financial Resources
1	Liang Huang (2018a)	Math	0.021	0.131	0.008	/
2	Liang Huang (2018b)	Reading	0.009	0.1	0.002	/
3	Liang Huang (2018c)	Science	0.023	0.117	0.019	/
4	Xiangyun Li, Ping Wei (2014a)	Chinese	0.243	0.441	-3.512	0.242
5	Xiangyun Li, Ping Wei (2014b)	Math	0.121	0.064	0.05	0.181
6	Xue Xia (2009)	Math	0.058	0.058	/	/
7	Yuhong Du, Yongmei Hu (2009a)	Math	0.001	0.219	0.096	-0.263
8	Yuhong Du, Yongmei Hu (2009b)	Chinese	0.101	0.222	0.239	-0.158
9	Haiping Xue, Weifang Min (2008a)	Math	0.126	0.17	/	0.123
10	Haiping Xue, Weifang Min (2008b)	Chinese	0.104	0.066	/	0.145
11	Yongmei Hu (2007a)	Math	0.114	/	0.106	0.122
12	Yongmei Hu (2007b)	Chinese	0.143	/	0.096	0.144
13	Yongmei Hu (2007c)	Math	0.231	0.232	0.204	/
14	Yongmei Hu (2007d)	Chinese	0.181	0.19	0.193	0.178
15	Xuehui An, Emily Hannum, Tanja Sargent (2008)	Total	-0.0021	-0.0021	/	/
16	Jennifer Adams (2012)	Math	0.085	0.053	/	/
17	Qiuyi Weng (2009)	Total	-0.219	-0.219	-0.052	/
18	Yanqing Ding, Haiping Xue (2008)	Total	0.081	0.081	/	0.168
19	Haiping Xue, Rong Wang (2009a)	Math	0.199	0.164	/	0.234
20	Haiping Xue, Rong Wang (2009b)	Math	0.235	0.143	/	0.322

**Table 4. Calculation of Effect Amount.**

	EQ	Effect Amount (Point Estimate)		SEM	Variance	Confidence Interval	Z Value	P Value
		Random Effect	Fixed Effect					
Overall Impact	20	0.093	0.089	0.027	0.01	[0.039-0.147]	3.393	0.001
Human Resources	18	0.121	0.060	0.020	0.00	[0.082-0.161]	5.972	0.000
Financial Resources	12	0.120	0.105	0.049	0.002	[0.024-0.215]	2.458	0.014
Material Resources	12	0.099	0.103	0.038	0.001	[-0.025-0.173]	2.629	0.009

Note: EQ: Effect Quantity; SEM: Standard Error of Mean.

**Table 5. Calculation of the Effect Amount of Each Sub-Variable of Human Resources.**

Human Resources Variables	EQ	Effect Amount (Point Estimate)		SEM	Variance	Confidence Interval	Z Value	P Value
		Random Effect	Fixed Effect					
Teacher Experience	8	0.185	0.177	0.059	0.003	[0.069,0.301]	3.315	0.002
Teacher Training	3	0.137	0.145	0.038	0.001	[0.062,0.211]	3.607	0.000
Teacher Education	8	0.144	0.160	0.023	0.001	[0.099,0.188]	6.292	0.000
Teacher Title	8	0.101	0.081	0.025	0.001	[0.052,0.151]	3.996	0.000
Teacher Qualifications	11	0.134	0.109	0.030	0.001	[0.075,0.193]	4.478	0.000
Student-Teacher Ratio	6	0.150	0.154	0.032	0.001	[0.089,0.212]	4.763	0.000
Teacher-Student Ratio	3	0.263	0.015	0.196	0.038	[-0.120,0.647]	1.346	0.178

Note: EQ: Effect Quantity; SEM: Standard Error of Mean.

**Table 6. Calculation of Effect Size of the Sub-Variable of Material Resource.**

Material Resource Variables	EQ	Effect Amount (Point Estimate)		SEM	Variance	Confidence Interval	Z Value	P Value
		Random Effect	Fixed Effect					
Computer Networking Rate	3	0.032	0.032	0.006	0.000	[0.020,0.043]	5.307	0.000
Number of Computers Per Student	3	-0.012	-0.012	0.008	0.000	[-0.027,0.002]	-1.659	0.097
Per Capita Fixed Assets	2	0.238	0.238	0.103	0.011	[0.037,0.439]	2.325	0.020
Construction Area Per Student	1	-0.052	-0.052	0.033	0.111	[-0.704,0.600]	-0.156	0.876
Classroom Area Per Student	4	0.112	0.106	0.045	0.002	[0.201,2.485]	2.485	0.000
Number of Books Per Student	5	-0.106	-0.040	0.173	0.030	[-0.445,0.234]	-0.610	0.542
Area Per Student	4	0.222	0.265	0.048	0.002	[0.129,0.315]	4.664	0.000

Note: EQ: Effect Quantity; SEM: Standard Error of Mean.

not large, so this result needs to be treated with caution.

## Regulatory Effect Analysis

According to the above analysis, it is known that heterogeneity exists between samples, and the source of heterogeneity is not caused solely by sampling errors. This paper explores possible sources of heterogeneity through the analysis of regulatory effects. In the meta-analysis literature related to student learning outcomes, moderating variables are usually selected from research disciplines, research stages, and research areas (Gu & Hu, 2018; Zheng, et al. 2018; Wang & Hu, 2018). Zhang et al. proposed that subgroup analysis can also be divided from professional perspectives such as research quality, design schemes, and statistical perspectives (Zhang, et al., 2015), and the principles of subgroup analysis and adjusted variable analysis are similar, so this perspective can also Select the manipulated variable. Therefore, this paper selects seven variables as research subject, research area, research period, research design, research method, document type and data type as moderator variables. Because the results of the analysis of the adjustment effects of human resources input, material resources input, and financial resources effects of the school are consistent with the overall analysis results, they are limited in space and only report the analysis results of the overall adjustment effects (see **Table 7**).

From the results in **Table 7**, it can be seen that the research subject ( $QB = 36.128, p < 0.001$ ), the research area ( $QB = 9.762, p = 0.045$ ), and the data type ( $QB = 11.604, P = 0.003$ ) are the main reasons for the difference in the effect amount. There is a significant difference in the amount of effect between different disciplines. The impact of school resource investment on Chinese and mathematics is significant, and the amount of effect is 0.171 and 0.123, respectively. It shows that the school's investment in resources will increase by one standard deviation. Students' language performance will increase by 0.171 standard deviations, and students' mathematics performance will increase by 0.123 standard deviations. Different regional effects are not the same, but except for the eastern region, the effect amount is not significant. The effect amount of the results of studies conducted in the central region and the eastern part of the country, and in the central and eastern parts of the country, shows a positive and significant effect with the range of [0.081, 0.193].

## Robustness Test

After calculating the research results, further publication bias testing and sensitivity analysis are needed to ensure the reliability of the research results. Publication bias means that statistically significant positive research results are easier to publish than statistically insignificant negative research results. If there is a publication bias, the combined effect amount will be greater than the actual effect amount, so the combined effect amount calculated in the fifth step needs to be corrected. There are usually two types of publication bias testing methods: the funnel graph method and the Egger test. The former determines whether there is a publication bias by checking whether the fun-

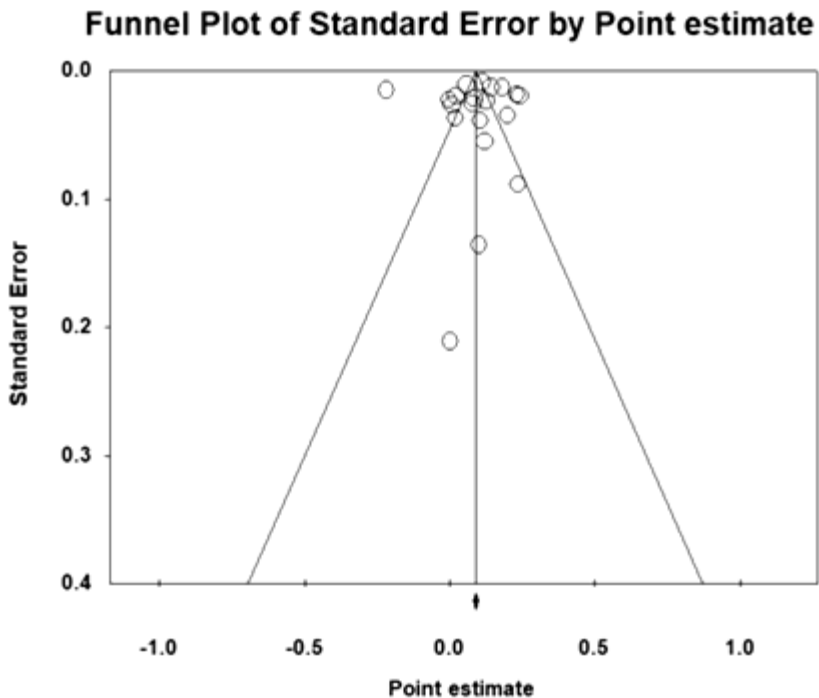
**Table 7. Analysis of Regulatory Effects.**

Manipulated Variable (Coding)		K	Q <sub>B</sub>	ES	95% CI	P
Output Variable (Output)	Chinese	5	36.128 (p<0.0001)	0.171	0.126-0.216	<0.001
	Mathematics	10		0.123	0.080-0.166	< 0.001
	Science	1		0.023	-0.016-0.062	0.250
	Reading	1		0.009	-0.044-0.062	0.739
	Total	2		-0.048	-0.238-0.143	0.625
Study Area (Aera)	Nationwide (N)	1	9.762 (p=0.045)	0.081	0.030-0.132	0.002
	Central (M)	2		0.193	0.075-0.310	0.001
	West (W)	9		0.115	0.069-0.160	<0.001
	Central and Eastern (EM)	4		0.149	0.100-0.198	<0.001
	East (E)	4		-0.043	-0.187-0.102	0.563
Research Section (Grade)	Elementary School (P)	8	1.365 (p=0.505)	0.118	0.073-0.164	<0.001
	Middle School (S)	11		0.074	-0.038-0.86	0.194
	High School (H)	1		0.081	0.030-0.132	0.002
Research Design (Study Design)	Quasi-Longitudinal Research (QL)	12	2.551 (p=0.110)	0.133	0.096-0.171	<0.001
	Non-longitudinal research (FL)	8		0.042	-0.065-0.148	0.444
Research Method (Method)	HLM	17	2.363 (p=0.124)	0.113	0.078-0.147	<0.001
	OLS	3		-0.077	-0.316-0.162	0.529
Literature Type (Lt)	Papers (J)	15	1.949 (p=0.163)	0.074	-0.009-0.158	0.080
	Non-Journal Papers (non-J)	5		0.144	0.093-0.195	<0.001
Data Sources	International data (G)	3	11.604 (P=0.003)	0.019	-0.01-0.047	0.209
	Large domestic monitoring data (C)	15		0.097	0.033-0.161	0.003
	Self-made experimental data (I)	2		0.193	0.075-0.310	0.001

nel graph is symmetrical, and the latter quantifies the publication bias by intercept. The funnel chart of the overall impact of school resources input on student performance is shown in **Figure 3**. The chart is approximately symmetrical, so there may be no publication bias, but to ensure the accuracy of the test, an Egger test is also required. Egger's test results also showed that there was no publication bias for this meta-analysis result ( $B0 = 0.043$ ,  $t = 0.016$ ,  $p1 = 0.494$ ,  $p2 = 0.987$ ).

Sensitivity analysis refers to whether the results change with the analysis conditions (Xia, 2005). The fail-safe N method is usually used to judge the possibility of publication bias to change the meta-analysis conclusion (Zeng & Yao, 2018). The larger N is, the more studies need to be included and the more stable the results. Generally, it is necessary to increase the sample size to be  $5k + 10$  or more of the existing sample size to determine that the result is stable (Rosenthal, 1979). The coefficient of insecurity

**Figure 3. Funnel Chart of the Impact of School Resource Input on Student Performance.**



calculated in this study is  $N = 1,676$  ( $\alpha = 0.050$ ,  $p < 0.0001$ ), so the conclusion can be proved to be robust.

## Discussion

### School Resource Investment Significantly Impacts Student Performance

The effect amount of school resources on student performance is 0.093. Since the standard regression coefficient is used as the effect amount in this study, an increase of one standard deviation in school resource investment will increase student performance by 0.093 standard points. It can be seen that the impact of school resources on student performance is very significant. The results of this study are consistent with the results of Greenwald et al. regarding 60 studies from the USA, but the results are slightly larger than those of Greenwald et al. This shows that the effect of Chinese school resource investment may be greater than that of the United States, and it also shows that the Chi-

nese school resource investment is relatively insufficient, and the marginal efficiency of resource investment is still at the marginal increasing stage, and it has not reached the optimal input level.

## **The School's Investment in Human, Financial and Material Resources Significantly Affects Student Performance, and Human Resources are More Effective**

This study finds that different resources invested in schools have different effects on students. Among them, the school's human resources investment has the best effect, with an effect amount of 0.121. An in-depth analysis of the impact of various variables on school human resources input found that teacher experience, teacher education, teacher qualifications, teacher training, teacher titles, and student-teacher ratios all have a positive and significant impact on student performance. The research results are consistent, and they all conclude that teachers are the most important factor affecting student performance (Hedges, et al., 1994; Hattie, 2015).

Teachers have always been considered to be an important factor affecting student performance. Nye et al. found that nearly 7%-12% of differences in student performance are caused by teachers (Nye, et al., 2004). Rowe et al. studied that only schools with effective teachers can be called effective schools (Rowe & Rowe, 1993). In addition, Hattie, through a meta-analysis of more than 800 students' academic achievements, obtained "teachers" as the main reason for education excellence, and praised teachers as the "holy grail of teaching" (Hattie, 2015). However, the teachers that Hattie refers to are not just teachers 'human capital factors such as their education, qualifications, and experience, but more influences on teachers' teaching, such as teaching strategies and teacher-student relations. Therefore, after drawing the conclusion that teacher resources investment, especially teacher experience, teacher qualifications, teacher qualifications, teacher training, teacher titles, student-teacher ratios have a positive impact on student performance, further research on its impact mechanism, namely teacher human capital, is needed. How do you influence student performance? In the current research on the relationship between teacher human capital and student achievement, more attention is paid to whether it has an impact, the degree of influence and direction, and less attention to whether its impact mechanism is through the influence of teacher human capital on teacher teaching style and student performance, or through teaching. Strategies to influence student achievement, or to achieve impact through other means need further exploration in the future.

The second is financial resources. In the past meta-analysis of investment in education funding, it was considered that the impact of education funding on student performance was small. How to use is more important than the amount of funds (Hanushek, 1989; Hanushek, 2003). Rolle also reached this conclusion, arguing that a large amount of investment is not necessary, and more importantly, how to use existing resources more efficiently (Rolle, 2004). In contrast, a series of studies by Hedges et al. found that educational investment has a positive and systematic impact on student per-

formance, and thus refutes the view that financial investment has only a limited impact on student performance (Hedges, et al., 1994; Hattie, 2015). Our results are roughly consistent with the results of Hedges, which found that the investment of school financial resources has a positive and significant impact on student performance. However, in our research, the impact of financial resources input on student performance is not inferior to human resources, with an effect amount of 0.120, which is only 0.001 lower than the effect amount of human resource investment. This is slightly different from the conclusion that Hedges et al found that teachers are more important. The reasons may be caused by the selected variables and samples, or they may be caused by different national conditions between China and the United States.

The last is the investment of material resources, with a standardization coefficient of 0.099, which is less than the effect of the school's financial and human resources, but the impact cannot be underestimated. In the analysis of input of different material resources, computer networking rate, fixed assets per student, classroom area per student, and school area per student significantly affect student performance.

## **The Effect of School Resource investment Varies by Subject, Region, and Data Type**

From the results of the adjustment effect, it can be found that the effect of school resource investment varies in different disciplines and regions. Among them, the subject of Chinese language and mathematics is more susceptible to impact, while the impact on other subjects is not significant. There may be two reasons for this research result: first, the difference caused by the uneven sample size; second, in China, Chinese language and mathematics are considered basic subjects, and they often get more education and teaching resources. Therefore, the impact of changes in school resources input on mathematics and Chinese subjects is more obvious.

The effect of school resource investment in different regions is also different, and the effect is better in the western region. The reason may be that, in addition to the uneven sample size, compared with the eastern region, China's central and western regions have a slightly lower level of economic development and insufficient economic strength. In particular, the western region has a weak economic foundation and limited investment in school resources. In this case, a slight increase in school resource investment in the central and western regions may produce better results, that is, the marginal efficiency of school resource investment is higher than in the east. For example, Ling used the data envelopment method to evaluate the efficiency of China's urban education financial expenditure, and found that there is a problem of pure technical inefficiency in urban education in China, and the pure technical efficiency of the eastern region is lower than that of the central and western regions. This shows that although the eastern region is rich in resources, the utilization efficiency of educational financial resources is not high and needs to be further improved (Ling, 2015). In recent years, China's investment in school resources in the central and western regions has increased significantly. The growth rate of financial education funding is significantly higher than that

in the eastern regions, especially in the poor regions (Yu, 2019). Therefore, we ask whether the efficiency of school resource utilization is affected by the economic level of the school's location, whether the education input has a "ceiling effect", and the optimal input level should be an explanation, etc. All these need to be studied further.

Different data sources have different effects on the investment of educational resources. The effect of international data is the smallest, and the effect of self-edited data is the highest. This result may be related to the rigor and representativeness of data compilation. There is a possibility that the self-edited data is not as rigorous as the international data and large domestic data, resulting in a high effect amount.

## **Conclusion and Perspective**

### **Conclusion and Inspiration**

This study used meta-analysis to analyze 11 literatures on the impact of Chinese school resource investment on student performance, a total of 20 effect quantities. The research results found that: (1) The overall impact of school resources on student performance is significant (the effect amount is 0.093,  $p = 0.001$ ), especially in master thesis and doctoral dissertation. (2) Compared with material resources, school human resources the input effect is even better, with affect amounts of 0.121 and 0.120 respectively. The effect of material resource investment is the lowest, but the impact is also very important. The effect amount is 0.099. (3) In human resources input, teacher experience, teacher education, teacher qualification, and teacher training, teacher title, and student-teacher ratio all have a positive and significant impact on student performance; among the material resources, computer networking rates, fixed assets per student, classroom area per student, and school area per student significantly affect student performance. (4) From a disciplinary perspective, the impact of school resource investment on Chinese and mathematics is more significant, and from a regional perspective, the impact on central and western regions is more significant.

Based on the analysis above, we believe that the input of human, material and financial resources in schools can promote the improvement of student performance. China's current investment in school resources is inadequate in terms of human, material and financial resources. It is necessary to continue to increase, and in the face of effective educational resources, we should consider how to allocate these resources more effectively in order to make the development of education better, faster and more balanced. For each school, in the face of limited educational resources, we should consider how to make more effective use of these resources, and how to make internal school deployment more effective. Therefore, we believe that China still needs to increase investment in school resources, especially increase financial resources and investment in schools in the central and western regions. At the same time, it is necessary to strengthen the input and allocation of teacher resources, and effectively improve the treatment of teachers. At the same time, increase teacher training, increase investment in teacher resources in weak schools and regions, and build a more reasonable and sufficient and efficient teacher team. On this basis, we should further strengthen the research on edu-

education input and output, better grasp the laws, and improve the efficiency of resource utilization through scientific decision-making, and better promote student development.

## Perspective

Because China does not currently have a unified measurement tool for student performance, it is difficult to obtain uniform and nationally comparable student performance data. And the complexity of school-level input data also makes it difficult for researchers to obtain this part of the data. Therefore, in this study, the comparability between results needs to be further discussed. Although they have been standardized, different measurement tools and different processing methods may still affect the results. In addition, due to the late start of quantitative research in the Chinese education industry and the existence of non-standard reports, the number of studies that can be included and the number of effect sizes are small. Therefore, the results of this study need more research for further verification.

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# Substitution or Complementation: The Relationship between School Education and Shadow Education

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**Abstract.** *In order to explore the relationship between school education and shadow education, this study applied two-level Bernoulli Model to estimate the school-level determinants of private tutoring by analyzing the data of PISA 2015 of four regions of China (Beijing, Shanghai, Jiangsu, and Guangdong). The results indicated that: (1) the four regions have large scale of private tutoring ranging from 58.7% to 74.0% for science, mathematics, and reading; (2) the participation rate of private tutoring in villages is much higher than that in cities; (3) the quality of school teachers significantly negatively affects the likelihood for receiving tutoring. Shadow education plays both substitutional and complementary roles for school education, and the growth of shadow education is in accompany with the low quality of school education in rural areas but with high quality of school education in urban areas. Instead of increasing Education resources and improving infrastructure, increasing teacher quality will reduce the participation probability of private tutoring.*

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## **Introduction**

**S**HADOW education, which is also called private tutoring, has been becoming of great popularity in China, especially in developed regions, such as Beijing, Shanghai, and Guangdong. In 2014, 48.9%-58.1% of elementary students and 66.8%-74.4% of middle school students received private tutoring in Shanghai (Zhang & Bray, 2016). In Beijing, 60.5% of elementary students and 58.4% of middle school students attended private tutoring in 2015 (Lu, 2016). Early in 2012, the participation rate of tutoring in Guangzhou ranged from 51.7% to 73.1%. With the global expansion of private tutoring, a growing number of studies explored the factors underlying the demand for private tutoring. Macro-factors, such as culture, education competition, and development of economic, have significant impact on the demand of tutoring. For example, Confucianism, one of the cultural factors, places value on education and instills a hard work ethic on children, is often mentioned as the “soil” (driver) for private tutoring (Zhu, 2013). The high-stakes examination exhibits great demand for tutoring as well as other supplementary learning activities. The growing of family income increases the chance to purchase tutoring service for their children, and institutionalization of public schooling stimulates parents and students to seek extra learning activities (Park et al., 2016). Family background, gender, and ethnic minorities are also strongly associated with the development of tutoring. However, before embarking on the factors underlying the development of tutoring, it's necessary to explore the definition and nature of shadow education. The term of shadow education refers to various type of tutoring, and the metaphor of “shadow” highlights the relationship between private tutoring and regular schooling. Private tutoring exists only because of the existence of regular education though; its shape and size change following that of the regular education; the curriculum in the “shadow” ones mimics the curriculum inside the regular schools and changes accordingly (Bray, 1999). The relationship means that the development of private tutoring can be explained by the public education, and it also reflects the development of education quality and equity.

Some debates exist about the relationship between regular education and shadow education. First, when the mainstream education system is perceived to be of poor quality, parents and students may be motivated to seek extra forms of academic learning in private market, so some studies have attempted to find a link between quality of public schooling and demand for private tutoring. Popa and Acedo (2006) noted that the backdrop of reduced funding for public schooling, increasingly poor population and teachers' low salary were the reasons for the increasing of private tutoring in Eastern Europe. In Korea, students from schools with higher student-teacher ratios tended to spend more time in private tutoring (Kim & Lee, 2010). Similarly, Dang (2007) found that as teacher quality increased in Vietnam, the amount of money families spent on private tutoring decreased. This assumption postulates that the inadequacies of public education stimulate the high demand for private tutoring. Given the limitations of public schooling in meeting individualized needs for learning, private tutoring may play a role as a substitutional institution. However, institutional perspective on educational devel-

opment offers a counter-explanation for the relationship between schooling quality and the demand for shadow education. Baker and LeTendre (2005) argued that growing demand for private tutoring reflected the institutionalization of public schooling. As the demand for educational opportunity and quality increases across social classes within and between countries, middle-class parents begin to seek private sources of additional learning for their children, because it becomes more difficult for them to influence regular schooling processes to maintain their children's advantage. For example, during the years of 2003 to 2010, the participation rate of private tutoring was much higher in urban areas and in high-quality schools in China (Xue & Ding, 2009; Tseng, et al., 2010). From this perspective, growing demand for shadow education is complementary to the regular education, which is supported by the theory of Supply and Demand as well as the theory of Effectively Maintained Inequality (EMI).

Based on the microeconomic theory of Supply and Demand, the demand for private tutoring depends on the quantity and quality of public education. When the quantity of public education cannot meet the demand of all the families, the families with high demand will take advantage of family capital to obtain more and better public education. While, when the supply of public schooling increases, the families with low demand can also receive regular education, the high-demand families will seek out-of-school activities to keep their advantage to access to higher education (Dang & Rogers, 2008). Xue (2015) employed EMI to indicate the relationship between regular education and shadow education, and they mentioned that when compulsory education basically universal has not been achieved, the core of education competitive is the access chance to regular education for students from different social classes. When the compulsory education basically universal is completed, the core of education competitive is the quality of school education. When the government takes measures to decrease the gap of educational quality between urban and rural areas, and between different schools, the core of education competitive will shift from educational quality to shadow education.

Thus, more empirical study is in need to verify whether the demand for shadow education is driven by the quality of public education. Is growing demand for shadow education due to the poor quality of school education, being substitutional to regular education, or due to the high quality of public schooling, being supplementary to regular education? Although previous studies indicated that students from better schools are more likely to receive private tutoring (Xue, 2009; Tseng et al., 2006), the dataset of these two studies were collected from urban cities in 2004 and 2009, when the compulsory education has not been completed. In order to explore the relationship between shadow education and regular school education, this study applies two-level Bernoulli Model to estimate the school-level determinants of private tutoring by analyzing the data of PISA 2015 of four regions of China including Beijing, Shanghai, Jiangsu, and Guangdong.

## **Methods**

## **Sample**

This study uses the data of the PISA 2015 of four regions (Beijing-Shanghai-Jiangsu-Guangdong). PISA program has been sponsored by the Organization for Economic Co-operation and Development (OECD) every three years since 2000. It applied two-stage stratified sampling to randomly select 9,841 students of 286 schools in the four regions, and the weighted sample covered 96% of all the 15-year-old students. Apart from the international assessment of mathematics, reading, and science, and the survey also collected extensive background information of teachers and schools.

## **Variables**

Previous empirical studies have found that students' family background, demographic and academic ability are related to their participation in private tutoring (Bray, et al., 2014; Choi & Park, 2016; Li & Hu, 2017), and this study will control these factors to estimate the impact of school-level factors on students' probability of receiving private tutoring.

Education quality will be measured from three dimensions, i.e., education input, education process and education output. Items measuring education input and education process are usually taken as independent variables, while items measuring education output are used to be dependent variables (Hanushek, 1986). Education input variables include education resources, quality of teachers, and quality of students (Shavelson & Baxter, 1992). Education resources include a questionnaire with 8 items about school resources, the school principals' perceptions of potential factors hindering the provision of instruction at school. The quality of teachers includes the index on staff shortage, which is derived from 4 items, as well as the proportion of teachers with bachelor or master degree. The quality of students is measured by the average ESCS of students' family background. Education equity, which is called quality of education opportunity, emphasizes that students from different ESCS background should have equal access to education (Coleman, 1966). In China, educational equity is also called "education balance", measured by three disparities, i.e., urban-rural disparity, region disparity and individual disparity (Wu, 2010). This study will analyze the relationship between education quality and shadow education by exploring the urban-rural disparity and schooling disparity in receiving tutoring. For a more detailed description of the variables, refer to **Table 1**.

## **Data Analysis**

A two-level Bernoulli model that is also called two-level hierarchical generalized linear model (HGLM) was used to estimate the effects of various student- and school-level variables on students' participation in private tutoring. The two-level Bernoulli model was used because student-level variables nested in the school-level, and the dependent variable is a dummy variable indicating whether or not the student participates in private tutoring. The level-1 and level-2 models are as follows:

Level-1 model:

$$Y_{ij} = \log\left(\frac{P_{ij}}{1 - p_{ij}}\right) = \beta_{0j} + \sum \beta_{ij}X_i + \varepsilon_{ij}$$

Level-2 model:

$$\beta_{0j} = \gamma_{00} + \sum \gamma_{0s}K_j + \mu_{0j}$$

$$\beta_{ij} = \gamma_{i0}$$

where  $X_i$  is a vector of level-1 control variables,  $\beta_{ij}$  refers to regression coefficient of level-1,  $\varepsilon_{ij}$  is the error term for level-1;  $K_j$  is a vector of level-2 control variables,  $\gamma_{0s}$  refers to regression coefficient of level-2,  $\mu_{0j}$  is the error term for level-2. (Only intercept term is random, and the coefficients of level-2 are fixed)

## Results

### Descriptive Statistics

**Table 2** shows the results of the descriptive statistics. In general, the participation rate of science, mathematics and reading tutoring is 58.7%, 74%, and 63.4%, respectively in the four regions. The academic achievement of students from cities, high quality schools and high ESCS families is better than that of the students from villages, low quality schools, and low ESCS families. But the scale of tutoring is larger in villages, low quality schools, and low ESCS families than in their counterparts. Comparing with the high school students, middle school students received more tutoring, but the academic achievement of high school students is much higher than middle school students. There are significant intergroup disparities in the distribution of participation in private tutoring and students' performance regarding urban-rural areas, institutional, family backgrounds, and individual ability. The results, that the participation rate of private tutoring in villages is much higher than that in towns and cities, and the lowest ESCS families have the highest participation rates, are totally different from the results of Xue's report, from which the participation rate of tutoring is much higher in undeveloped county-level towns, poor quality schools than that in capital cities, high quality schools in 2009. The results based on PISA2015 indicated that the prevalence of tutoring might gradually transfer from urban areas to rural areas, and the tutoring market has also begun to attract students from poor families.

Due to the availability of data, most of previous studies mainly focused on the prevalence of tutoring, as well as the determinants and impacts of tutoring, few studies explored what kind of tutors the students preferred. Our study estimates the selection and distribution of tutors to explain the relationship between school education and shadow education. **Table 3** indicates that regular teachers are most frequently used tutors, with over 50% of students indicated tutoring by their own teachers. Around 29%-

**Table 1. Variable Descriptions.**

Variable	Variable Descriptions
<b>Dependent Variable</b>	
Private Tutoring	0=no, 1=yes; three subjects: science, mathematics, reading.
<b>Independent Variables</b>	
<b>Student-Level</b>	
Female	0=male, 1=female.
Study Program	0=middle school, 1=high school.
Students' Ability	The mean score of science, mathematics, and reading.
Students' Educational Expectation	1= middle school, 2=two-year high school, 3= high school, 4=vocational high school, 5=three-year college, 6=four-year college and above.
Family Economic, Social And Cultural Status (ESCS)	Parents' highest education level, parents' highest occupation status, and home possessions compute the index of family ESCS. More the scores are, higher the family ESCS status is.
<b>School-Level</b>	
School Location	A village, hamlet or rural area (fewer than 3000 people)(reference group), a small town (3,000 to about 15,000 people), a town (15,000 to about 100,000 people), a city (100,000 to about 1,000,000 people), a large city (with over 1,000,000 people).
Quality of Education Resources	The shortage of school Education resources is scaled using four items: a lack of educational material (e.g. textbooks, IT equipment, library or laboratory material), inadequate or poor quality educational material (e.g. textbooks, IT equipment, library or laboratory material), a lack of physical infrastructure (e.g. building, grounds, heating/cooling, lighting and acoustic systems), inadequate or poor quality physical infrastructure (e.g. building, grounds, heating/cooling, lighting and acoustic systems). More the scores are, lower quality of the schooling resources is.
Quality of Teachers	(1) Staff shortage is derived from four items: A lack of teaching staff, inadequate or poorly qualified teaching staff, and a lack of assisting staff, inadequate or poorly qualified assisting staff. More the scores are, lower quality of teachers is. (2) The proportion of teachers with bachelor qualification (PROAT5AB), the proportion of teachers with master qualification (PROAT5AM), the proportion of fully certified teachers (PROATCE).
Quality of Students	The mean scores of students' family ESCS aggregated in school level. More the scores are, higher the family ESCS status of school is.
<i>Note: 1. PISA 2015, additional instruction is translated to 课外辅导 in the mainland of China, Which is also called 课外补习. 2. Family economic, social and cultural status is ESCS.</i>	

40% of the students choose specialized tutors working for a business or organization. Non-specialized tutors are the least used. The academic achievement of the students choosing specialized tutors is the highest, whereas the students choosing non-specialized tutors are the lowest.

To explain why the participation rate of tutoring in village and small town is much higher than that of in city, we explored whether the choice of tutors varies across the groups of students. The choice of tutors varies significantly across students' school- and family- backgrounds. Regular teachers are mostly used tutors for the students from village schools, but low quality schools with smallest number of teachers with master qualification and lowest ESCS families. Although special tutors working for a business

**Table 2. The Distribution of Private Tutoring in the Four Regions.**

	Science		Mathematics		Reading	
	%	Mean Scores	%	Mean Scores	%	Mean Scores
Total Sample	58.7	518	74.0	531	63.4	494
<b>School-Level</b>						
<b>Regions</b>						
A village	65.0	488	80.3	506	74.4	466
A small town	61.6	495	76.9	509	70.2	471
A town	59.2	527	74.7	541	66.0	502
A city	52.0	544	65.0	555	56.0	524
A large city	55.0	587	71.2	593	48.4	566
	$\chi^2=54.1$ $p<0.001$	$F=392.8$ $p<0.001$	$\chi^2=88.4$ $p<0.001$	$F=307.6$ $p<0.001$	$\chi^2=304.7$ $p<0.001$	$F=379.5$ $p<0.001$
<b>The proportion of Teachers with Master Qualification</b>						
The Lowest 1/4	62.4	469	75.6	483	73.2	441
The Lower 1/4	57.7	505	72.2	517	65.6	4801
The Upper 1/4	56.4	528	73.7	539	61.9	501
The Top 1/4	58.3	561	74.4	572	52.0	541
	$\chi^2=16.4$ $p<0.001$	$F=598.2$ $p<0.001$	$\chi^2=6.9$ $p<0.1$	$F=541.2$ $p<0.001$	$\chi^2=205.1$ $p<0.001$	$F=657.8$ $p<0.001$
<b>Student-Level</b>						
<b>ESCS</b>						
The Lowest 1/4	62.4	475	75.6	488	73.2	444
The Lower 1/4	57.7	516	72.2	530	65.6	496
The Upper 1/4	56.4	534	73.7	547	61.9	515
The Top 1/4	58.3	589	74.4	597	52.0	567
	$\chi^2=16.4$ $p<0.001$	$F=674.5$ $p<0.001$	$\chi^2=6.9$ $p<0.1$	$F=575.4$ $p<0.001$	$\chi^2=205.1$ $p<0.001$	$F=714.0$ $p<0.001$
<b>Study Program</b>						
Middle school	64.4	498	79.6	510	71.3	473
High school	51.0	567	66.4	579	52.4	547
	$\chi^2=144.2$ $p<0.001$	$t=-36.5$ $p<0.001$	$\chi^2=189.4$ $p<0.001$	$t=-36.6$ $p<0.001$	$\chi^2=309.1$ $p<0.001$	$t=-37.3$ $p<0.001$

are the mostly used for the students from lager cities, high quality schools with largest number of teachers with master qualification and highest ESCS families. Although more and more disadvantage students start to access to tutoring market, the quality of tutoring they receive might be not as good as the advantage students. We can also spec-

**Table 3. Type of Tutors Used by the Students Receiving Tutoring.**

	Science		Mathematics		Reading	
	%	Mean Scores	%	Mean Scores	%	Mean Scores
1. One of My Regular Teachers	53.4	496	52.3	510	56.4	468
2. Other Regular Teachers in School	36.7	505	33.2	515	29.6	479
3. Specialized Tutors Works for A Business or Organization.	39.9	510	34.4	524	29.6	486
4. Non-Specialized Tutors	16.2	470	13.6	488	14.4	439

*Note: this is a multiple-choice question. 1. The teacher is one of my regular teachers in this year's school courses; 2. The teacher regularly teaches students my age in school but is not my teacher in any of my regular school courses; 3. The teacher mainly works for a business or organization specialized in additional instruction; 4. The teacher is not specialized teaching personnel (e.g. a student).*

**Table 4. Type of Tutors Used Across Groups of Students.**

	Science				Mathematics				Reading			
	1	2	3	4	1	2	3	4	1	2	3	4
<b>Region</b>												
A Village	58.9	37.0	41.5	19.3	55.1	32.2	37.0	17.3	57.9	30.3	33.2	15.6
A Small Town	61.2	36.9	37.5	17.8	59.1	33.3	31.9	14.7	62.5	30.8	29.6	16.1
A Town	56.6	36.5	34.6	16.2	58.2	31.2	29.9	13.2	59.3	27.9	25.6	14.2
A City	51.6	35.1	36.6	15.9	53.0	31.6	31.3	14.2	53.5	27.4	26.6	14.8
A Large City	36.1	37.1	48.7	11.8	34.7	36.0	42.7	9.4	40.9	29.0	34.0	9.1
<b>The Proportion of Teachers with Master Qualification</b>												
Low 1/3	62.3	38.6	37.5	20.3	61.7	32.7	31.1	17.1	61.9	31.6	29.7	16.8
Middle 1/3	52.8	35.9	37.6	14.8	53.0	33.2	34.1	13.2	57.0	28.7	28.3	14.0
Top 1/3	43.2	35.6	45.8	12.8	40.4	34.0	39.0	10.3	47.2	27.8	31.5	11.4
<b>ESCS</b>												
The Lowest 1/4	64.9	33.7	33.3	21.8	63.5	31.5	27.6	19.0	63.5	29.8	27.0	18.4
The Lower 1/4	55.0	37.1	36.5	16.6	57.1	30.5	32.1	13.7	59.2	28.5	26.2	14.7
The Upper 1/4	53.9	37.5	40.0	15.1	50.8	33.4	36.4	11.7	55.2	30.4	32.5	12.8
The Top 1/4	39.4	38.8	50.4	11.1	37.9	37.3	41.7	10.2	43.8	29.6	34.4	10.1

*Note: 1= one of my regular teachers; 2=other regular teachers in school; 3=specialized tutors working for a business or organization; 4=non-specialized tutors. Data are percentages.*

ulate that most of regular teachers still provide paid tutoring, especially in village and small town (**Table 4**).

## **The Determinants of Private Tutoring**

Given participation rate of private tutoring varies across groups of students, we analyzed the determinants of receiving private tutoring by employing a two-level Bernoulli model. **Table 5** displays the results.

For the individual student-level factors, students' gender, education expectation, and ability, are significantly related to the probability of receiving private tutoring. Female students are more likely to receive science and reading tutoring than male students. Education expectation can significantly positively predict the probability of receiving science and mathematics tutoring. Students' academic achievement has significantly negatively associated with the demand of private tutoring, which means Chinese students may seek tutoring for remedial purposes. It is obvious that students from prosperous families (high ESCS) have more chance to receive private tutoring than those from low economical families (low ESCS).

For the school-level factors, we constructed three models to estimate the impact of schooling quality on private tutoring. In model 1, we explored the relationship between the locations of schools with the demand of tutoring. In model 2, we estimated the impact of Education resources and teachers' quality on the demand of tutoring. In model 3, we discussed whether the quality of students can predict the probability of receiving tutoring. The results showed that: (1) Students from village schools are more likely to receive private tutoring than students from (large) city schools, and the quality of education resources, teachers, and students drives this result. With that when we put the variables of the quality of education resources, teachers, and students into the model 3, students from large city schools become less probability to receive private tutoring than students from village schools. (2) The quality of school teachers negatively predicts the possibility of receiving tutoring. The lower proportion of teachers with master qualification the schools have, the students are more likely to receive science, mathematics and reading tutoring. Students from schools with lower proportion of fully certified teachers have more possibility to take reading tutoring.

The urban-rural disparity does appear to affect the likelihood of participating in private tutoring, and students of village schools are more likely to receive private tutoring. The shortage of high-quality teachers in the village schools stimulates parents to purchase tutoring service to substitute for regular school education.

## **Conclusion and Discussion**

This study applies two-level Bernoulli model to estimate the school-level determinants of private tutoring by analyzing the data of PISA 2015 conducting in four regions of China (Beijing, Shanghai, Jiangsu and Guangdong). The major findings are summarized below:

Table 5. Results of the Two-Level Bernoulli Model.

	Science			Mathematics			Reading		
	M1	M2	M3	M1	M2	M3	M1	M2	M3
<b>Fixed Effects</b>									
Small Town	0.04 (0.34)	0.01 (0.27)	-0.18 (0.20)	0.08 (0.27)	0.12 (0.23)	0.10 (0.24)	-0.09 (0.39)	0.01 (0.32)	0.08 (0.29)
Town	-0.17 (0.36)	-0.24 (0.32)	-0.51 <sup>†</sup> (0.21)	-0.19 (0.28)	-0.25 (0.26)	-0.28 (0.29)	-0.37 (0.41)	-0.27 (0.37)	-0.09 (0.35)
City	-0.46 (0.34)	-0.56 <sup>†</sup> (0.28)	-0.53 <sup>†</sup> (0.24)	-0.67 <sup>†</sup> (0.27)	-0.71 <sup>†</sup> (0.23)	-0.75 <sup>†</sup> (0.26)	-0.81 <sup>†</sup> (0.41)	-0.75 <sup>†</sup> (0.32)	-0.56 <sup>†</sup> (0.32)
Large City	-0.44 (0.33)	-0.26 (0.29)	-0.41 <sup>†</sup> (0.22)	-0.30 (0.26)	-0.11 (0.25)	-0.18 (0.29)	-1.10 <sup>‡</sup> (0.39)	-0.66 <sup>†</sup> (0.33)	-0.31 (0.36)
Resources Shortage		0.08 (0.08)	0.09 (0.08)		0.13 (0.07)	0.13 <sup>†</sup> (0.07)		0.04 (0.09)	0.07 (0.08)
Staff Shortage		-0.08 (0.07)	-0.09 (0.07)		-0.10 (0.06)	-0.09 (0.07)		-0.03 (0.07)	-0.07 (0.06)
PROAT5AB		0.35 (0.37)	0.49 (0.41)		0.36 (0.38)	0.28 (0.41)		-0.06 (0.44)	0.36 (0.46)
PROAT5 AM		-2.38 <sup>‡</sup> (0.65)	-1.75 <sup>†</sup> (0.81)		-1.73 <sup>‡</sup> (0.61)	-2.13 <sup>‡</sup> (0.76)		-3.88 <sup>‡</sup> (0.72)	-1.88 <sup>‡</sup> (0.83)
PROATCE		-2.17 (1.41)	-2.08 (1.39)		-1.36 (1.22)	-1.42 (1.22)		-2.09 <sup>†</sup> (1.15)	-1.81 <sup>†</sup> (1.04)
Average ESCS			-0.14 (0.12)			0.09 (0.11)			0.45 <sup>†</sup> (0.03)
High School	0.01 (0.16)	0.01 (0.16)	0.01 (0.16)	-0.33 <sup>†</sup> (0.19)	-0.33 <sup>†</sup> (0.19)	-0.33 <sup>†</sup> (0.19)	-0.20 (0.18)	-0.21 (0.18)	-0.21 (0.18)
Girls	-0.21 <sup>‡</sup> (0.07)	-0.21 <sup>‡</sup> (0.08)	-0.21 <sup>‡</sup> (0.08)	-0.06 (0.08)	-0.06 (0.08)	-0.06 (0.08)	-0.32 <sup>‡</sup> (0.08)	-0.33 <sup>‡</sup> (0.08)	-0.33 <sup>‡</sup> (0.08)
Ability	-0.67 <sup>†</sup> (0.07)	-0.68 <sup>†</sup> (0.07)	-0.68 <sup>†</sup> (0.07)	-0.82 <sup>†</sup> (0.07)	-0.82 <sup>†</sup> (0.07)	-0.82 <sup>†</sup> (0.07)	-0.89 <sup>†</sup> (0.07)	-0.91 <sup>†</sup> (0.07)	-0.91 <sup>†</sup> (0.07)
Education expectation	0.09 <sup>†</sup> (0.03)	0.10 <sup>†</sup> (0.03)	0.10 <sup>†</sup> (0.03)	0.12 <sup>†</sup> (0.03)	0.12 <sup>†</sup> (0.03)	0.12 <sup>†</sup> (0.03)	0.04 (0.03)	0.05 (0.03)	0.05 (0.03)
ESCS	0.14 <sup>†</sup> (0.05)	0.14 <sup>†</sup> (0.05)	0.14 <sup>†</sup> (0.05)	0.22 <sup>†</sup> (0.05)	0.22 <sup>†</sup> (0.05)	0.22 <sup>†</sup> (0.05)	0.09 <sup>†</sup> (0.04)	0.09 <sup>†</sup> (0.04)	0.09 <sup>†</sup> (0.04)
Intercept	0.53 <sup>‡</sup> (0.07)	0.50 <sup>‡</sup> (0.06)	0.48 <sup>‡</sup> (0.06)	1.22 <sup>‡</sup> (0.06)	1.19 <sup>‡</sup> (0.06)	1.21 <sup>‡</sup> (0.06)	0.81 <sup>‡</sup> (0.08)	0.75 <sup>‡</sup> (0.06)	0.70 <sup>‡</sup> (0.06)
<b>Random Effects</b>									
Variance Component	0.37	0.34	0.34	0.35	0.33	0.33	0.53	0.46	0.41
$\chi^2$	847.3 <sup>‡</sup>	793.4 <sup>‡</sup>	787.5 <sup>‡</sup>	750.6 <sup>‡</sup>	704.1 <sup>‡</sup>	702.8 <sup>‡</sup>	1030.0 <sup>‡</sup>	906.8 <sup>‡</sup>	838.4 <sup>‡</sup>
Note: Standard Error of Mean in parentheses; * $<0.1$ , <sup>†</sup> $<0.05$ , <sup>‡</sup> $<0.01$ .									

Similar to the previous studies (Zhang & Bray, 2016; Lu, 2016; Wu, 2014), shadow education is prevalent in developed areas of China. The four regions we studied have a large scale of private tutoring, and the participation rate of private tutoring on Science, Mathematics and Chinese is 58.7%, 74.0%, 63.4%, respectively.

The distribution of demand for private tutoring in the four regions of China has the following characteristics: village-city gap, interschool disparity, and regular teachers as paid tutors. In 2015, students from village schools with low quality are more likely to receive private tutoring than the students from city schools that have high quality. This finding is different from the previous studies, for example, according to Lei (2005), both the participation rates of private tutoring and tutoring expenditure in urban areas are much higher than that in rural areas in Beijing and Jiangsu. The following discussion is mainly concerned with the reason why the private tutoring is more prevalence in village than in city in 2015. First of all, when the goal in the effort to make nine-year compulsory education basically universal has been attained, the demand for school education increases in undeveloped areas, but the poor quality of regular education cannot meet students' demand, so parents have to send their children to tutoring centers. Second, the results showed that regular school teachers are mostly used tutors for the disadvantage students, while specialized tutors are most likely used for the advantage students. Perhaps regular teachers might be the best choice for disadvantage students in villages and small towns, where do not have any specialized tutoring organizations, because the fee is low and it's convenient to study in teachers' home. However, it is the low quality of public schools in villages and ineffective teaching practices in school education stimulates parents seeking private tutoring service as a "substitution" for regular school education. In fact, the phenomenon of regular teachers as paid tutors is common in China, especially in villages and small towns. Although school teachers are strictly prohibited from providing tutoring in China, it seems that this official policy has not been effectively implemented. Tutoring provided by mainstream teachers is a double-edged sword, the dark side is that we cannot prohibit the school teachers from reducing the coverage of regular lessons or revealing examination answers in tutoring class to foster demand for tutoring. What's worse, teachers might trade off their own students with other teachers to avoid being penalized by the policy.

The village-city gap and interschool disparity on the quality of regular education have significant association with the prevalence of shadow education. The results indicated that students from public schools in villages have more probability to receive private tutoring and poor quality of teachers in school lead to high demand of private tutoring in 2015. During the past ten years, the scale of shadow education in villages began to expand. We attempt to explain this change based on the theory of Supply and Demand: when compulsory education basically universally has not been attained, shadow education is more common in city. Because the quantity of public education cannot meet the demand of disadvantage families in village, they have to fight for more public education. However, advantage families in city who enjoy the quantity and quality of public education purchased tutoring service as a "complementation" to make sure they will success in education competition. When compulsory education basically universal-

ly has been completed, shadow education becomes more popular in village and small town. For the quality of education cannot meet the demand of disadvantage families in village and small town, they have to purchase tutoring service as a “substitution” to obtain more entrance opportunity. Although families in large cities still purchase tutoring service to keep their advantage in university opportunities, the participation rate of private tutoring increased slower than that in village and small town because the quality and equity of public education has been further developed in these areas.

In overall, shadow education plays both substitutional and complementary role in school education, that the growth of shadow education is in accompany with the low quality of school education in village and small town, where families purchase shadow education as a “substitution” to obtain more entrance opportunity when the quality of school education cannot meet their demand. The growth of shadow education develops with the high quality of school education in city, where families purchase shadow education as a “complementation” to make sure they keep their advantage in education competition. However, shadow education is mostly provided by regular teachers of public schools in village and small town, and in city, most of the students choose specialized tutors.

It's necessary to re-examine the problem of school education according to the development of shadow education. First, there is still urban-rural disparity in educational quality. To decrease the participation probability of private tutoring, the government should increase teacher quality of regular education, with the increasing of the quality of education resources and improving of the infrastructure building. Second, the phenomenon of regular teachers as tutors is common, especially in undeveloped areas, such as villages and small towns. “Why do school teachers provide paid tutoring? Do the students participate in tutoring provided by teachers on their own? Are there any “corruption” behavior for school teachers to attract more students to participate in their tutoring class?” Schools and educational institution should pay more attention to these problems. Third, no matter the “substitutional” role of shadow education in village, or the “complementary” role in city, shadow education seems to replicate educational inequality outside school, which has negative impact on the quality and equity of regular education. Of course, it remains to be verified whether the results of the relationship between regular education and shadow education based on the data of these four regions are applicable to other provinces and cities.

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# Peer Effect of Middle School Students: A Natural Experiment Based on Puberty Developmental Maturity

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**Abstract.** *Peer is an important factor affecting the academic performance of middle school students. Domestic research has discussed this issue, but there are still some shortcomings in solving endogeneity aspects. Therefore, this study used the random effect of natural changes in pubertal development and maturity of middle school students in two years adjacent to the same class to identify peer effects due to changes in pubertal development and maturity; at the same time, first-order difference and quantile regression are used to solve the endogeneity problems in general regression analysis. We found that girls' developmental maturity is significantly negatively related to their performance, and boys' developmental maturity is significantly positively related to their performance, which indicates that there is a gender difference in the impact of adolescent developmental maturity on academic performance of middle school students. In addition, the peer effect is also heterogeneous, that is, in overall, the lower the development maturity of girls in a class, the more conducive to the improvement of student performance; the higher the maturity of students in class, the more conducive to the improvement of student performance. The findings of this study have certain policy implications for adjusting the school age of school-age children.*

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**Keywords:** *Peer Effect; Natural Experiment; Developmental Maturity; Heterogeneity*

## Introduction

IN the framework of the educational production function, family, school, student personal characteristics and peers are all important factors affecting student academic performance. In the past few decades, a large number of studies have conducted a lot of fruitful discussions on the factors of families, schools, and students, and can accurately estimate the role of each factor; however, there is no clear conclusion about the role of peers, especially in the mainland of China, and is particularly very rare on the peer effects in middle school students. Therefore, this study attempts to analyze the peer effect of middle school students in mainland of China.

## Literature Review

Peer effect is also called peer effect. Research on the role of peers in education can be traced back to the Coleman report (1966). The study found that peers, families, teachers, schools and other factors affect students' academic performance. Most of the early studies were limited to the discussion of the relationship between peers and academic performance (Caldas & Bankston, 1997; Link & Mulligan, 1991), and did not overcome the endogeneity problem in estimation. In 2000, Hoxby (2000b) for the first time analyzed the peer effect in schools by using the random factors of the birth of the population, and relatively accurately estimated the peer effect in education. Hoxby's idea of using natural experiments to overcome endogeneity to estimate peer effects has gradually gained importance in subsequent related research.

## Concepts, Pathways, and Heterogeneity

The definition of peer is the first step in the study of peer effects, and it is also a major challenge in the study of peer effects. Early studies often chose classmates (Sacerdote, 2001; Zimmerman, 2003), class level (Ding & Lehrer, 2007), and grade level (Hoxby, 2000b; Hanushek, et al., 2003) as individual student peers. In recent years, there have been an increasing number of researches using students' self-reported friends (Ilmarinen, et al., 2017; Lavy & Sand, 2018) as peers for analysis. This social network-based peer effect is obviously more real, but data acquisition is difficult and generally difficult to achieve.

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In addition to defining peers, clarifying the concept of peer effects is also the basis for conducting related research. There has been no consensus on the concept of peer effects. At present, there are several representative views: Sacerdote (2011) believed that the peer effect includes almost all external factors that are not market- or price-driven, such as peer background, current behavior, or educational attainment. Lu & Zhang (2007) believed that the peer effect is the interaction between people, which directly affects the performance of relevant actors. Du & Yuan (2016) defined the peer effect in education as the influence of the background, behavior, and performance of peers in dormitories, classes, grades, or schools on student performance or behavior. There are various ways to influence this effect. Based on the above analysis, the author considers the effects of natural characteristics, background, behavior, performance, and non-cognitive characteristics of peers in schools on student performance, behavior, and non-cognitive skills as peer effects.

There are many ways in which the peer effect can play a role, and peer performance is not the only way to generate peer effects. Hoxby (2000b) believed that the ways of peer effect include: mutual help between students; students' inherent ability to affect peers through the spillover effect of knowledge and the impact on class positioning; behaviors affected by the environment also affect peers; disability, race, gender, and family income also play a role; peer effects can also take a part through the attitudes of teachers and administrators to students.

Earlier studies on peer effects were mostly limited to the description of correlations. Strategies such as ordinary least squares were often used, but these methods did not solve the problem of endogeneity well. One of the challenges in estimating peer effects is endogeneity. According to the theories of Manski (1993), Manski (1995), and Moffitt (2000), the endogeneity of the peer effect estimation mainly comes from Selection Bias and Reflection Problem. Parents often choose a school, class, or even a teacher for their children based on their family economic and social background, making it difficult to simply attribute changes in students' academic performance to peers, which is the so-called self-selection bias. Individual students and their peers live in the same environment and receive the same education, and there will inevitably be mutual influences between each other. That is, students are not only affected by peers, but also students themselves. Moreover, these two effects often occur at the same time, and it is often difficult to separate them, which causes the problem of simultaneous bias in the estimation of peer effects.

Peer effects are also heterogeneous, meaning that students of different types or abilities may be affected to different degrees and directions by peers. Hoxby (2000b) found that the peer effect is asymmetric. Subsequent research has gradually verified this conclusion, but the existing researches on the direction of heterogeneity were not completely consistent. The conclusions mainly include two major categories: the smaller the differences in student abilities or types, the better the student's development (Ding & Lehrer, 2007; Hoxby & Weingarth, 2005), and the larger the differences in student abilities or types, the better the student's development (Carman & Zhang, 2012; Vigdor & Nechyba, 2006). In addition, the identification of heterogeneity often uses two strate-

gies: interaction (Hoxby & Weingarth, 2005) or quantile regression (Ding & Lehrer, 2007; Hanushek, et al., 2003).

## **Recognition Strategy**

In recent years, with the continuous improvement of causal inference technology, the identification of peer effects has become more accurate. Natural experiments (Angrist & Lang, 2004; Hoxby, 2000b) and quasi-experimental studies have gradually attracted attention. The key to natural experiments is to find the appropriate random factors. Since Hoxby (2000b), the research of natural experiments has been favored by the social sciences. When it comes to natural experiments, you first need to clarify the relationship among Random Control Experiment, Natural Experiment, and Conventional Observational Studies.

Standard random experiments generally need to meet three conditions (Freedman et al, 2007). First, compare. Compare the differences between the experimental group and the control group after the experiment. Second, random assignment. The subjects were randomly assigned to the control group and the experimental group. Third, manipulation or intervention by researcher. The researchers gave different experimental treatments to the experimental group and the control group. The ideal random experiment needs to fully meet the three conditions mentioned above. Traditional observational research can often only meet the first condition, that is, “comparing” the differences between different research objects, and the conditions of “random allocation” and “human intervention / control” are often difficult to meet. Natural experiment is a research method between random experiment and traditional observational research.

Natural experiments are different from traditional observational studies. Because the former can meet the first condition of random experiments, that is, “comparison”, it can at least guarantee that the sample is random (Random) or approximately random (As Random), which is also a natural experiment closer to random experiments than traditional observational research. The reason is that it should be said that randomness is the key to natural experiments (Dunning, 2012). Therefore, finding enough exogenous and uncontrolled factors is a prerequisite for conducting natural experiments. “Nature” in natural experiments often comes from some phenomena in social life: for example: (1) exogenous shocks: disasters, climate, economic fluctuations; (2) individual biological factors: birth, aging, disease, death, etc. (3) geographical location: topography, borders; (4) man-made purely random events: draw lots, test scores, government policies, etc. In addition, natural experiments are also observational studies, because natural experiments also cannot satisfy the condition of “control” in random experiments, and the experimental process cannot be controlled by researchers. Natural experiment, as a causal inference strategy closest to random experiment, provides us with a reliable identification strategy, which overcomes the disadvantages of traditional observational research to a certain extent.

However, we must also admit that it is often difficult to provide the conditions for causal analysis of everything we want to evaluate in social life. The analysis of specific groups based on natural experiments can often only be regarded as a local average

treatment effect (LATE) (Dunning, 2012). The evaluation of natural experiments is generally carried out from three aspects, Plausibility, Credibility, and Relevance (Dunning, 2012). Plausibility refers to the use of quantitative and qualitative methods to demonstrate that the allocation process of natural experiments is random; Credibility emphasizes that the causal relationship of the model is convincing, that is, the disposal variable is independent of other factors that affect the outcome variable; Relevance refers to the problem and intervention to be studied Whether it is substantially related to the external validity of the experimental results. The excellent properties of natural experiments in solving endogeneity make it an important choice for identifying peer effects. Hoxby (2000b) used the random factors of birth changes to identify the effect peer brought by gender and race. The key of this research is to cleverly find the natural changes in student gender and changes in student performance caused by natural changes in race. It overcomes the corresponding endogenous problem, thus setting a precedent for identifying the peer effect by natural experiments.

## **Effective Natural Factors**

As a multi-disciplinary issue, the study of peer effects has been involved to varying degrees in economics, psychology (Ilmarinen, et al., 2017), and sociology (Cheng, 2017). In recent years, influenced by multidisciplinary, interdisciplinary, and transdisciplinary trends, different disciplines have learned from each other in terms of research content and research methods. Affected by psychology and sociology, a lot of researches have been done on the relationship between adolescent developmental maturity and students' academic performance. The maturity of puberty is a natural phenomenon of life, and it is a normal physiological phenomenon that does not transfer by human will. Puberty refers to the physical development of people who were originally able to have children (McKechnie, 1979). Physiological research often uses the two indicators of Pubertal Status and Pubertal Timing to describe the physical development of adolescence. The former refers to changes in the body of an individual, including secondary sexual characteristics, and the latter refers to the sooner or later of these changes compared to their peers. To characterize the differences in pubertal development in different individuals, the term "pubertal mature pubertal development" was introduced, and it is often measured as soon as puberty enters.

Adolescent developmental maturity has a certain effect on individual cognitive skills and non-cognitive skills, and this effect is direct, that is, developmental maturity often depends on the sooner or later of puberty. A study by Beltz and Berenbaum (2013) found that the effects of adolescents entering puberty on their cognitive development and brain development differ by gender. They used the characteristics of male first spermatorrhea and female menarche as the proxy variables for puberty. The study found that boys who entered early adolescence performed better on cognitive tests than boys who entered later adolescence; for women, this effect was not significant. Cavanagh and Riegle-Crumb (2007) also used girls' self-reported menarche as a proxy variable for early and late puberty. They found that girls who matured earlier had lower GPA in high school, were more likely to encounter failure in high school courses, and graduated

from high school is less likely. Research by Daniel et al. (1982) found that maturity at puberty affects both cognitive and non-cognitive performance of students. Compared with boys with normal developmental maturity, boys who have late maturity (secondary sexual development score below 80% of participants) have worse cognitive scores and lower expectations from their parents; they have earlier maturity of boys performed better on cognitive scores than boys of moderate maturity and later maturity. Kristian and Tuomas (2017) used the development of adolescent secondary sexual characteristics as a proxy variable for early and late puberty. The study found that students who matured later (including boys and girls) have lower cognitive scores, worse academic performance, and Future income will be lower. This study believes that there is a difference between men and women entering puberty, but this is not the reason for the differences between men and women in cognitive ability and academic performance (Koerselman & Pekkarinen, 2017).

In summary, adolescent developmental maturity is a natural factor that has a direct impact on students' academic performance, parental expectations, etc., and most studies support the conclusion that boys mature earlier and girls mature later are more favorable for student development. In this sense, the influence of peer development maturity on student achievement can be regarded as a peer effect. Based on this, this study attempts to supplement and develop the existing research from the following three aspects: First, we have overcome the problems of self-selection bias and synchrony bias commonly encountered in the estimation of peer effects. This study uses natural experiments on changes in adolescent developmental maturity to more accurately estimate the peer effect brought by adolescent developmental maturity. Second, it enriches the related theories of peer effects. This research combines the research results of psychology and physiology, and focuses on the influence of the physiological characteristics of peers on students' academic performance, which enriches the research content of peer effects to a certain extent. Of course, puberty developmental maturity is just one type of peer effect, and the overall analysis of all types of peer effect has yet to be explored. Third, the external validity of the study is higher. In the past, researches on peer effects mostly focused on a certain school, region, or project. The research on peer effects at the national level is still relatively limited. This study uses the tracking data of middle school students in mainland China to analyze this problem to a certain extent. This improves the applicability of the conclusion.

The following structural arrangement of this article is as follows: The third part introduces the model and data sources; the fourth part gives descriptive statistical results, the results of econometric analysis, and the robustness test; the fifth part gives research enlightenment and shortcomings.

## **Research Design**

### **Empirical Strategy**

#### ***Natural Experiment***

The recognition of peer effects is inseparable from the clever application of causal inference technology. Therefore, finding suitable random factors is very important for the construction of the entire model. This factor must not only affect the academic performance of peers, but also ensure that it is not affected by human factors. We use the maturity of middle school students as a random factor to identify peer effects. In the process of choosing a school and class, parents rarely consider the maturity of their classmates, and developmental maturity often has a significant impact on their academic performance. In addition, from the perspective of the educational production function, the factors affecting the average grade of the class include factors such as family characteristics, school characteristics, and personal characteristics, but many factors will not change significantly in the short term. For example: the overall ability of class students, the family economic background of the class students as a whole, the school environment, the characteristics of teachers, etc., and other unobservable factors in the short-term changes are random. Therefore, this article uses the number of students who entered puberty (that is, the first male nocturnal emission or female menarche) in the same class as the proxy variable for student development and maturity, and then eliminates other factors that affect the average grade of the class through a first order difference. The effect of changes in the developmental maturity of middle school students on the change in the average grade of a class during the year can be regarded as a peer effect. This design for identifying peer effects can be regarded as a natural experiment. The basic model established in this article is as follows:

$$A_{c j g} = \alpha_{0 g} + \alpha_1 P_{c j g}^{\text{mat}} + \alpha_2 S_{c j g} + \alpha_3 I_{c j g} + \alpha_4 F_{c j g} + \varepsilon_{c j g} \quad (1)$$

$$A_{c j g-1} = \alpha_{0 g-1} + \alpha_1 P_{c j g-1}^{\text{mat}} + \alpha_2 S_{c j g-1} + \alpha_3 I_{c j g-1} + \alpha_4 F_{c j g-1} + \varepsilon_{c j g-1} \quad (2)$$

$A_{c j g}$  represents the average score of the academic performance (cognitive ability test) of grade  $c$  in class  $g$  of school  $j$ ,  $P_{c j g}^{\text{mat}}$  represents the maturity of the students in the class, and the corresponding coefficient  $\alpha_1$  is the size of the companion effect concerned in this article;  $S_{c j g}$  represents the share of students in the same class School characteristics;  $I_{c j g}$  represents the average true ability of students in the same class;  $\varepsilon_{c j g}$  is an unobservable error term.

We can obtain the following equation by first difference.

$$\Delta A_{c j g} = \alpha_0 + \alpha_1 \Delta P_{c j g}^{\text{mat}} + \Delta \varepsilon_{c j g} \quad (3)$$

Where the unobservable factor  $\varepsilon_{c j g}$  is random, then  $\Delta A_{c j g}$  in Equation (3) has a normal distribution with a mean value of 0. Equation (3) gives the relationship model between the development maturity of the students in the class and the average performance of all students in the class.  $\Delta A_{c j g}$  includes the results of students who have entered adolescence. Therefore, in order to further overcome the problem of possible simultaneous errors, we replace the student's grade  $\Delta A_{c j g}$  in formulas (1) and (2) with the

average grade  $\Delta A'_{c_jg}$  of students who have not yet entered adolescence in the same class, that is,  $\Delta A'_{c_jg}$  means that those in class c of class g of school j have not entered adolescence. The average score of the students' academic performance, so through the difference, we can get a model similar to (3):

$$\Delta A'_{c_jg} = \varphi_0 + \delta_1 \Delta P_{c_jg}^{mat} + \Delta \mu_{c_jg} \quad (4)$$

and the corresponding coefficient  $\delta_1$  is the size of the peer effect concerned in this article.

### Heterogeneity Model

Studies (Ding & Lehrer, 2007; Hoxby & Weingarth, 2005) show that the peer effect is heterogeneous, that is, the direction and magnitude of peer influence on students at different levels may be different. We use the strategy of conditional quantile regression (Koenker & Bassett, 1978) proposed by Koenker and Bassett to identify the heterogeneity of peer effects. Combined with the research object of this article, we set the quantile regression model as follows:

$$Q_\theta(\Delta A'_{c_jg} | \Delta P_{c_jg}^{mat}) = \alpha_0 + \alpha_1 \Delta P_{c_jg}^{mat} + \Delta \varepsilon_{c_jg} \quad (5)$$

$\Delta A'_{c_jg}$  represents the value of  $\theta$  quantile given  $\Delta P_{c_jg}^{mat}$ . Quantile regression can estimate any percent and minimize the MSE function to obtain the estimator, which is equation (6).

$$\alpha_1^\theta = \operatorname{argmin} \left\{ \sum_{\Delta A'_{c_jg} \geq \varphi_0 + \delta_1 \Delta P_{c_jg}^{mat}} \theta \left| \Delta A'_{c_jg} - (\varphi_0 + \delta_1 \Delta P_{c_jg}^{mat}) \right| + \sum_{\Delta A'_{c_jg} < \varphi_0 + \delta_1 \Delta P_{c_jg}^{mat}} (1 - \theta) \left| \Delta A'_{c_jg} - (\varphi_0 + \delta_1 \Delta P_{c_jg}^{mat}) \right| \right\} \quad (6)$$

### Data Sources

The data used in this article are micro-data from China Education Panel Survey (CEPS). CEPS uses PPS sampling to design a sampling frame based on the “six population” in four stages, covering 28 county-level units (counties, districts, and cities) randomly selected across the country with the average education level and population ratio as stratified variables. The sample is a good representation of mainland China. During the sampling process, 1-2 classes were sampled in each grade of each school, and all students in the selected classes were sampled. The survey took the 2013-2014 school year as a baseline and surveyed 10,279 seventh-grade students. In the 2014-2015 school year follow-up survey, a total of 9,449 seventh-grade students were successfully followed up with a follow-up rate of 91.9%, and this is the representative of the situation in the

country. The survey also surveyed the backgrounds of student parents, classroom teachers, class teachers, and school leaders. The relevant data can well meet the research needs of this article.

Each round of the CEPS survey will test the students' cognitive ability. The content of this test question does not involve the specific memorizing knowledge taught in the school curriculum, but measures the students' logical thinking and problem solving ability. Finally, the three-parameter project reflection theory (IRT) is used to convert the standard points into international standards and characteristics of national standardization. This study focuses on peer-level peer effects in schools and requires peer composition to remain stable for a certain period of time. As a result, we only kept data on 7,826 students from 184 classes in 96 schools that did not reclassify or merge during the two surveys. At the same time, 213 students who did not meet the study design<sup>1</sup> were deleted, and the remaining valid sample was 7,613<sup>2</sup> students in 184 classes of 96 schools.

## **Results**

### **Describe Statistical Results**

In combination with the literature review, this article summarizes the main factors that may affect the average grade of the class. **Table 1** gives descriptive statistics of the main variables. From **Table 1**, we can find that from the core variables, the scores of the 8th grade students' academic performance have decreased compared with the 7th grade; in the same class, the students' average maturity, girls' and boys' maturity during the year increased by approximately 50.12%, 39.69%, and 75.54%,<sup>3</sup> respectively. It can be seen that a higher proportion of boys have entered adolescence within two years.

From the perspective of family characteristics, compared with the seventh grade, the average maximum years of schooling of parents and the proportion of only children have declined, with 0.3 years and 1% respectively. The decline in parents' years of education may be caused by measurement errors, that is, the parents' education level was answered by the children in the first round of surveys, while the parents or their children's guardians answered in the second round of surveys. The decline in the proportion of only children may be related to the "The only child of one parent can have a second child" policy that was implemented nationwide in November 2013 and can be regarded as a random change.

The proportion of students with higher family socioeconomic status in the class increased by 1.5%, this is majorly related to the type of community in which the student lives to identify the family socioeconomic status of the participated student. It is possible for the student residence community to change within two years, but this change is random, and it is difficult to have a substantial impact on student development and maturity in the short term. In terms of school characteristics, the nature of the school has not changed in two years; the school ranking has declined slightly. Affected by factors such as measurement error, the above changes are all within acceptable ranges. Descriptive statistical results generally support the hypothesis of this study.

**Table 1. Summary Statistics of Main Characteristics.**

Description of Variables	Type	Mean	SD	Min	Max	N
<b>Core Variables</b>						
Class average score from students not entering the puberty in seventh grade <sup>[1]</sup>	Continuous	-0.171	0.581	-1.707	1.466	2,589
Class average score from students not entering the puberty in eighth grade	Continuous	-0.237	0.610	-2.021	1.267	2,589
Puberty maturity from all students in seventh grade <sup>[2]</sup>	Continuous	17.447	7.347	3	45	2,589
Puberty maturity from all students in eighth grade	Continuous	26.191	8.234	6	55	2,589
Puberty maturity from female students in seventh grade	Continuous	13.092	5.512	2	27	2,589
Puberty maturity from female students in eighth grade	Continuous	18.288	5.873	3	33	2,589
Puberty maturity from male students in seventh grade	Continuous	4.502	3.631	0	24	2,589
Puberty maturity from male students in eighth grade	Continuous	7.903	4.677	0	28	2,589
<b>Family Characteristics</b>						
The ratio of classroom high SES in seventh grade	Continuous	0.385	0.292	0	1	2,589
The ratio of classroom high SES in eighth grade	Continuous	0.400	0.288	0	1	2,589
Class average education highest years of parents in seventh grade <sup>[3]</sup>	Continuous	16.47	1.104	12.90	19	2,589
Class average education highest years of parents in eighth	Continuous	16.17	1.196	12.37	18.71	2,589
The ratio of classroom single-child in seventh grade	Continuous	0.410	0.256	0	0.969	2,589
The ratio of classroom single-child in eighth grade	Continuous	0.400	0.265	0	0.969	2,589
<b>School Characteristics</b>						
The property of school in seventh grade <sup>[4]</sup>	Discrete	1.095	0.408	1	4	2,589
The property of school in eighth grade	Discrete	1.095	0.408	1	4	2,589
The rank of school in seventh grade	Discrete	4.123	0.680	2	5	2,560
The rank of school in eighth grade	Discrete	4.174	0.755	1	5	2,589 <sup>[5]</sup>

Note:

- [1]. The cognitive tests score range of two wave survey is -2.029~2.710, -3.137~2.063 respectively, and CEPS using z-scores.
- [2]. Using the number of students entering the puberty (namely appearing the first spermatorrhea and menarche) as proxies of puberty maturity.
- [3]. Illiteracy, primary schools, junior secondary schools, secondary vocational schools, vocational high schools, regular senior secondary schools, higher vocational colleges, undergraduate schools and graduate schools and above denoted 0 year, 6 years, 9 years, 12 years, 12 years, 12 years, 12 years, 12 years, 16 years, 19 years, respectively
- [4]. The property of school includes public school, private school subsidized by the government, ordinary private school and private school for children of migrant workers, which is denoted by 1, 2, 3 and 4, respectively.
- [5]. There is a school that didn't complete the rank of school in eighth grade, so the sample size of the rank of school in seventh is 2589.

**Table 2. Puberty Maturity on Score for All Students.**

	<b>Puberty</b>	<b>R<sup>2</sup></b>	<b>N</b>
Scores	0.0386** (0.0193)	0.2932	7,114

*Note: 1. The table controls for class average education highest years of parents, the ratio of only-child from the same classroom and the ratio of classroom single-child and includes school fixed effects. The number of sample size is the number of students.  
2. Clustered standard errors are reported in parentheses and standard errors are clustered by class.  
3. \*\*: p<0.05.*

**Table 3. Peer Effects from Puberty Maturity.**

	<b>Puberty Maturity from All Students</b>	<b>Class Average Score from Students Not Entering the Puberty</b>
Puberty Maturity from All Students	0.0057*** (0.0011)	0.0009 (0.0020)
N	184	56
R <sup>2</sup>	0.0044	0.0001

*Note: 1. Robust standard errors is reported in parentheses  
2. Each column represents a separate regression and the number of sample size is the number of class.  
3. \*\*\*: p<0.01.*

**Table 4. Peer Effects from Puberty Maturity by Sex.**

	<b>Puberty Maturity from All Students</b>		<b>Class Average Score from Students not Entering the Puberty</b>	
Puberty Maturity from Female Students	-0.0106*** (0.0014)		-0.0142*** (0.0026)	
Puberty Maturity from Male Students		0.0376*** (0.0018)		0.0338*** (0.0037)
N	184	184	56	56
R <sup>2</sup>	0.0086	0.0595	0.0127	0.0334

*Note: 1. Robust standard errors is reported in parentheses  
2. Each column represents a separate regression and the number of sample size is the number of class.  
3. \*\*\*: p<0.01.*

## Econometric Analysis Results

The peer effect of adolescent developmental maturity: From **Table 2** in the natural experiment, it is not difficult to find that in controlling the family characteristics and adopting the fixed school effect method, from the perspective of the individual student, the student's developmental maturity and academic performance are related, that is, **Table 2** estimates the results, but this result is undoubtedly endogenous.

In order to further explore the causal relationship between student development maturity and student performance, we give the estimated results of formulas (3) and (4), which are the first and second columns of **Table 3**. We can find that the development maturity of the students in the class is positively related to the students' performance, but the R2 in both models is smaller. At the same time, through further analysis of the data, we found that in the samples used in column 1 and column 2 of **Table 3**, the number of boys accounted for 51.65% and 83.35%, respectively, and the number of boys had certain advantages. In addition, from **Table 1**, we can find that the ratio of girls entering adolescence increased by 39.69% within two years, and the proportion of boys entering adolescence increased by 75.54%. In summary, we believe that the results given in **Table 3** more reflect the impact of male students' developmental maturity on student performance, and do not fully characterize the impact of developmental maturity of all students, especially female students, on student performance. Existing physiology and psychological studies show that there is a gender difference in the impact of adolescent developmental maturity on males and females, that is, early maturity of boys and late maturity of girls are more favorable for individual development. Therefore, in this study,  $P_{cig}^{mat}$  in equation (1) was replaced by female development maturity  $P_{cig}^{gm}$  and male development maturity  $P_{cig}^{bm}$ , respectively. Equations (2) and (4) were treated the same, and new equations (3) and Equation (4). The estimation results are shown in **Table 4**.

After considering the gender differences in student development maturity, we found that the impact of development maturity on student performance became robust and the corresponding R2 became relatively reasonable. From the first column of **Table 4**, the maturity of the girls in the class is negatively correlated with the class average and is very significant. When we focus on the peer effect to students who have not yet reached puberty in the class, that is, as shown in column 3 of **Table 4**, students are still negatively affected by the maturity of the development of girls from the class, which is very significant. The research conclusions are basically the same. The study by Dubas et al (1991) found that the later the girls mature, the higher their academic performance ranks. From the second column of **Table 4**, the development maturity of the boys in the class has a very significant positive correlation with the average grade of the class. When we only focus on the impact of boys' developmental maturity on students who have not yet reached puberty in the class, the conclusion is still valid, as shown in column 4 of **Table 4**, that is, boys' developmental maturity has a positive predictive effect on student performance. The results of Dubas et al (1991) and Daniel et al (1982) are consistent. Both studies show that the sooner a boy matures, the higher his academic performance. The above results also confirm our results in **Table 3**, that is, the results in

**Table 3** mainly reflect the impact of male students' developmental maturity on student performance.

## Robustness Test

The maturity of puberty is a natural life phenomenon, but if there are factors related to both puberty development maturity<sup>4</sup> and academic performance, such as: Family economic and social status, learning pressure, then equation (3) the estimation results of equation (4) may be inconsistent. Therefore, this study analyzes the above factors one by one by sample. We divide the students' socioeconomic status and the learning pressure of the three major subjects into high and low according to the median, and perform regression based on formula (4). The results are shown in **Tables 5** and **6**.

From the second line of **Table 5**, the negative impact of the student's performance on the maturity of the girls in the class still exists in the subgroups with high socioeconomic status, low socioeconomic status, high math pressure, and low math pressure. This is basically consistent with the conclusions in columns 1 and 3 of **Table 4**, which shows that the conclusions of this article are relatively robust. From the fourth row of **Table 5**, the development maturity of the boys in the class is positively correlated with the academic performance in different groups. This is basically consistent with the conclusions in columns 2 and 4 of **Table 4**, which shows that the influence of family socioeconomic status and mathematical pressure on adolescent development and maturity is not serious, and it can basically guarantee that adolescent development and maturity exists independently as exogenous factors.

From the second row of **Table 6**, it is not difficult to find that the development maturity of class girls has always had a negative impact on student performance, which is consistent with the conclusions in columns 1 and 3 of **Table 4**. The development maturity of female students has a negative effect on student performance prediction. Looking at the fourth row of **Table 6**, the impact of the developmental maturity of the boys in the class on the student's performance is positive, indicating that the developmental maturity of adolescence is not seriously affected by the learning pressure of Chinese and English, and the regression results and benchmark regression results (**Table 4** columns 2 and 4) are closer. It can be seen that the basic conclusion of this study is relatively stable, that is, the learning pressure does not significantly affect the maturity of adolescence, so the latter can exist as an independent natural factor.

### *Peer Effect of Developmental Maturity under Different Conditional Quantiles: Heterogeneity Model*

**Figure 1** shows the impact of girls' maturity on the performance of non-pubertal students in different quantiles. The horizontal axis represents the conditional quantiles of class girls' developmental maturity, and the vertical axis represents the effects of girls' developmental maturity on performance under different conditional quantiles. In overall, the peer effect of girls' developmental maturity is heterogeneous. Student performance decreases with the increase of conditional quantiles, and has been shown to have a sig-

**Table 5. Peer Effects from Puberty Maturity by Sex: Robustness.**

	High SES	Low SES	High Pressure From Math	High Pressure From Chinese
Puberty Maturity from Female Students	-0.0069 (0.0047)	-0.0385*** (0.0084)	-0.0112* (0.0060)	-0.0203*** (0.0064)
Puberty Maturity from Male Students	0.0467*** (0.0067)	0.0075 (0.0087)	0.0565*** (0.0101)	0.0210*** (0.0061)

*Note: 1. Robust standard errors is reported in parentheses  
 2. All results are estimated by equation (4) and each cell represents a separate regression.  
 3. \*:  $p < 0.1$ , \*\*\*:  $p < 0.01$ .*

**Table 6. Peer Effects from Puberty Maturity by Sex: Robustness.**

	High Pressure from Chinese <sup>†</sup>	Low Pressure from Chinese	High Pressure from English	High Pressure from English
Puberty Maturity from Female Students	-0.0185 (0.0115)	-0.0148*** (0.0044)	-0.0300*** (0.0047)	-0.0069 (0.0057)
Puberty Maturity from Male Students	0.0080 (0.0100)	0.0491*** (0.0058)	0.0450*** (0.0063)	0.0187* (0.0096)

*Note: 1. Robust standard errors is reported in parentheses  
 2. All results are estimated by equation (4) and each cell represents a separate regression.  
 3. \*:  $p < 0.1$ , \*\*\*:  $p < 0.01$ .  
 †: In this subgroup, puberty maturity on score is not significant which result from that the number of size is small.*

nificant negative impact on most of the quantiles. Before the 70th quantile, the impact of class maturity on student achievement was similar to the regression results of OLS; after the 70th quantile, the negative impact of class maturity on student achievement was affected by the quantile. The increase of the point increases rapidly, and it is obviously larger than the regression result of OLS. The influence reaches the maximum value at the 90th quantile.

**Figure 2** shows the influence of boys’ developmental maturity on the average performance of non-pubertal students in different quantiles. The horizontal axis represents the conditional quantiles of class boys’ developmental maturity, and the vertical axis represents the impact of boys’ developmental maturity on performance in different conditional quantiles. Overall, the peer effect of boys’ developmental maturity is heterogeneous. Student performance improves with the increase of conditional quantiles, and the effect on almost all quantiles is always significantly positive. For the 10th to 30th quantiles, student performance decreases as the conditional quantile increases, and for

Figure1. Peer Effects in Different Quantiles in Male.

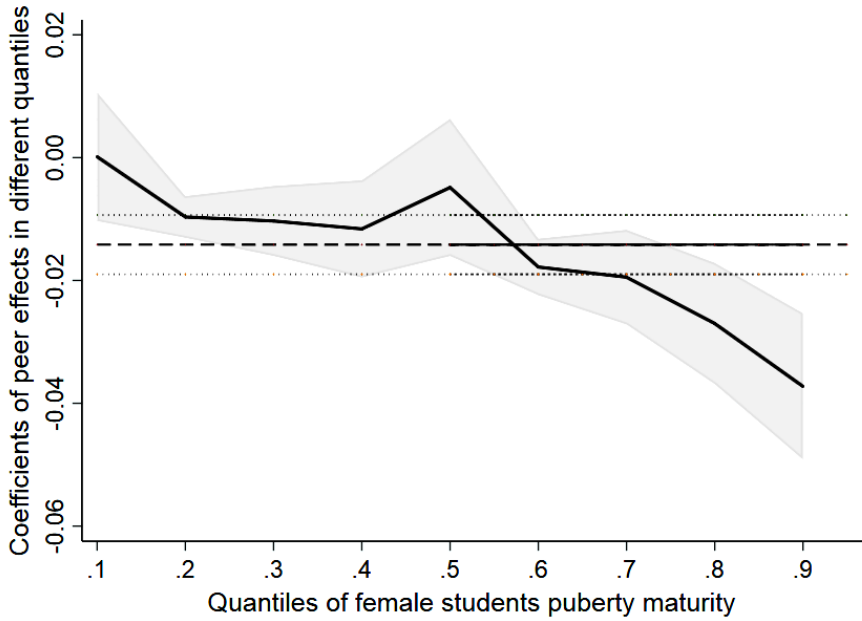
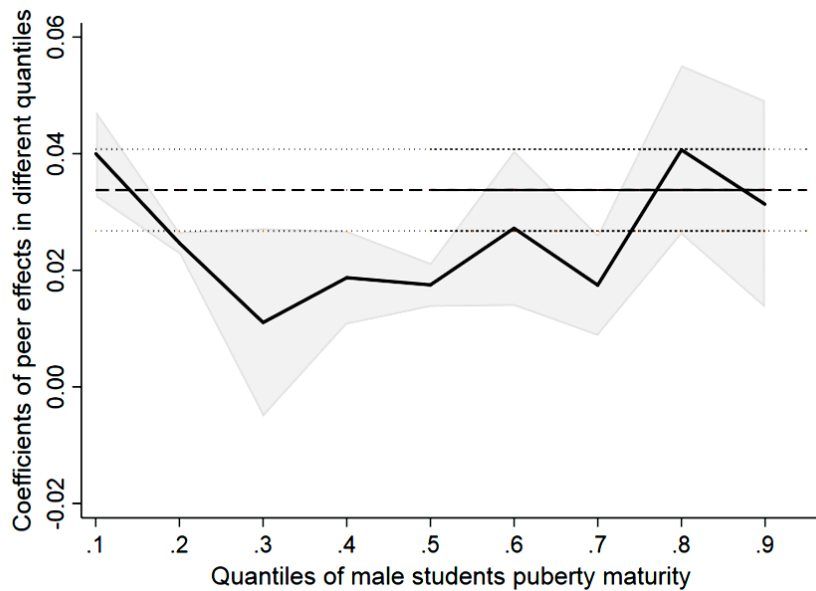


Figure 2. Peer Effects in Different Quantiles in Female.



the 30th to 80th quantiles, student performance increases as the conditional quantile increases. After the 80th quantile, the student's performance decreases again with the increase of the conditional quantile, and the effect reaches the maximum at the 90th quantile.

## **Conclusion and Discussion**

Peer effect, as a classic problem in economics, pedagogy, psychology, and sociology, is of great significance to school placement, school enrollment, and parents' choice of school. However, there are not many domestic studies on the peer effect in mainland China; especially the related studies that have effectively solved the endogenous nature are still scarce. We used the national survey data of CEPS to design natural experiments using changes in the development and maturity of middle school students, and empirically test the peer effect of middle school students in mainland China. This is one of the earlier studies in mainland China to analyze the peer effects of middle school students. This study found that peer maturity has an impact on the academic performance of middle school students, and that this effect has a gender difference. The developmental maturity of boys has a very significant positive correlation with the average class performance, while the developmental maturity of girls has a very significant negative correlation with the average class performance.

This study has certain policy implications for adjusting the school age of school-age children. We found that the peer effect of middle school students 'developmental maturity has gender differences, which confirms and expands the common sense that boys' mental maturity is later than that of girls. Therefore, from the perspective of adolescent development and maturity, the age at which boys and girls enter school should be different. The enrollment age of boys should be slightly behind that of girls of the same age, in order to give full play to the positive impact of higher development maturity and lower maturity of girls on classmates.

This article basically solves the endogenous problem of peer effect estimation, and has played a positive role in enriching related research. However, the following limitations exist: (1) This study analyzes the peer effect of middle school students from the perspective of adolescent development and maturity, but this is only one type of peer effect, and the overall analysis of all types of peer effects has not been achieved. The peer effect has various types and strong endogenous characteristics. It is very difficult to measure all kinds of peer effects completely. Therefore, in order to accurately measure peer effects, existing research can often only identify some types of peer effects. Of course, these studies are undoubtedly helpful for the subsequent overall analysis of all types of peer effects, which is the direction of future efforts. (2) In theory, the most ideal peer effect should be based on the analysis of friends, for example: analysis based on social networks, but this type of research often requires higher quality data, data acquisition is relatively difficult, and everyone's friends change often. It should be said that this type of peer effect is very effective, but it is also not easy to achieve, which is undoubtedly a point for future research.

## Notes

1. Refers to samples of boys who have entered their age at menarche and girls who have entered their age for the first time, and boys who have not responded to the age of their first sperm and girls who have not responded to the age of their menarche, as well as samples of menarche and the time when their first sperm is younger than 9 years old.
2. When considering only the results of adolescent students (e.g., columns 3 and 4 of **Table 4**), the valid sample is 2,589 students from 56 classes in 30 schools.
3. Female:  $(18.288-13.092) / 13.092 = 0.3969$ ; Male:  $(7.903-4.502) / 4.502 = 0.7554$ ; all students:  $(26.191-17.447) / 17.447 = 0.5012$ .
4. Studies have shown that girls 'menarche sooner or later, and boys' first sperm emission sooner or later are affected by factors such as genetics, nutritional status, economic income level, and pressure, and the impact of these factors on the maturity of men and girls can be attributed to differences in family economic and social status The resulting nutritional differences.

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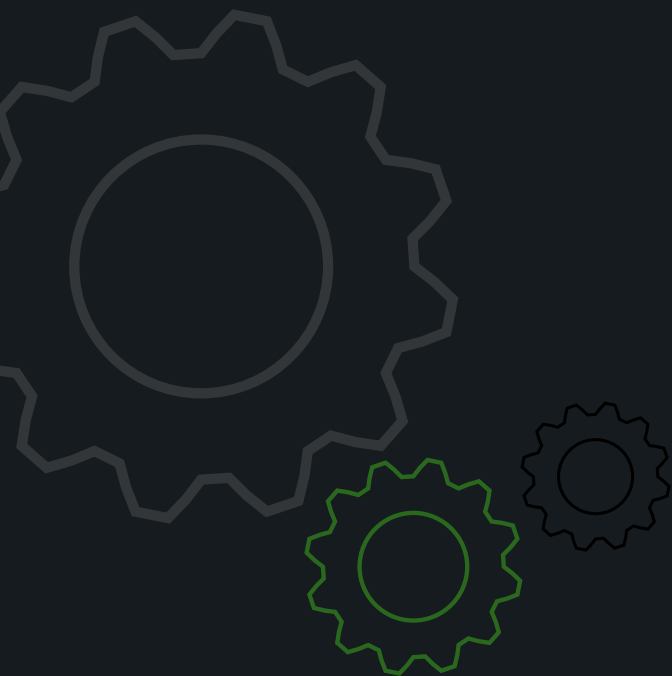
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