Fachbereich Erziehungswissenschaft und Psychologie

der Freien Universiteat Berlin

Determinants Influencing Educational Outcome Inequality in China:

The Role of Effort and Contextual Factors

Dissertation

zur Erlangung des akademischen Grades

Doktorin der Philosophie (Dr. phil.)

vorgelegt von

M. Ed.

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Berlin, 2023

The enclosed doctoral research work was accomplished from May 2018 until May 2023 under the supervision of Prof. Dr. Eva Jablonka and Prof. Dr. Uwe Gellert at the Department of Education and Psychology, Freie Universitat Berlin.

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Date of Defence: 15. 09.2023

Eidesstattliche Erklärung

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Abstract

The question of whether individual effort can mitigate the educational resource deficits linked to family background has been extensively debated in academic literature. Early studies suggested that differential effort might perpetuate or reinforce existing inequalities, as individuals from higher socioeconomic backgrounds were thought to possess certain "middle-class habits." However, more recent research contends that increased effort has the potential to offset or even compensate for family background disadvantages. It is widely acknowledged that dedicating more time and energy to learning can help narrow the achievement gap among students. Nevertheless, limited attention has been given to understanding the relative contributions of effort and contextual factors in shaping and potentially narrowing or widening performance disparities between students.

In the realm of educational equality, extensive empirical evidence suggests that educational outcomes are shaped by a complex interplay among various factors. Particularly, students' circumstances encompassing the family and school environment, are intricately related to their academic achievements. These include the level of effort exerted by students, parents, and schools. In addition, cognitive ability and other individual factors that are conceptualized as innate endowment, have been shown to play a crucial role in shaping academic achievement.

Despite the sophistication and breadth of research addressing these factors, there is still a dearth of studies, particularly within the Chinese context, that comprehensively investigate the relative significance of those factors in influencing students' learning progress and how they synergistically interact to give rise to disparities in academic achievement. Based on this observation, the question emerges: To what extent do circumstantial or effort-related factors exert substantial predictive effects on educational outcomes when the influence of innate endowments, such as cognitive ability, is adequately

controlled? Meanwhile, it is essential to recognize that socioeconomic background continues to exert implicit influences on educational outcomes, giving rise to careful consideration in the analysis.

By delving into these intricate dynamics, this thesis aims to gain a comprehensive understanding of the role of effort in educational inequality. It seeks to closely examine the relationships between the efforts made by families, schools, and students, and their respective impacts on educational outcomes. To achieve this goal, the following research questions will be explored:

1) What is the relative contribution of family support compared to school input in influencing students' academic achievement?

2) Can individual effort be considered an independent variable in determining students' academic success, and how does the level of student effort vary across different socioeconomic statuses?

3) If effort is indeed a distinct factor in determining academic achievement, which individual or group variable related to student, parental, and school effort is the most predictive of students' academic outcomes?

This thesis addresses the aforementioned research questions by conducting three sub-studies utilizing a robust panel data set from China. Its primary objective is to identify the factors that contribute to disparities in academic outcomes and forecast the areas where such disparities are more likely to occur. To achieve this, the analysis begins by employing both relative and absolute variable importance frameworks to examine potential predictors that significantly influence unequal academic performance. By doing so, it aims to uncover the key determinants of academic obstacles faced by junior high school students within the Chinese educational context. Furthermore, the thesis leverages machine learning regression models such as Random Forest, Lasso, Adaboost, and SVR. These models enable the extraction of the most influential features that play a crucial role in determining academic achievement.

Regarding the influence of cognitive ability on educational outcomes, the thesis adopts a comprehensive approach across its studies. In *Study I*, the innate endowment effect is treated as a clustered controlled variable, focusing on the combined impact of gender and personal characteristics based on family origin. It is important to note that this specifically excludes other dispositional (genetic) effects, such as noncognitive and cognitive abilities or talent. Additionally, in *Study II* and *Study III*, cognitive ability is explicitly considered as a control variable. In both studies, the outcomes of a cognitive ability test that was part of the Chinese panel data were used. This allows for a more precise examination of the role of cognitive ability and enhances the overall validity and reliability of the research findings.

The *first* sub-study of this thesis aimed to assess the relative importance of family support and school input variables in shaping students' academic achievements. Specifically, it sought to determine whether family support or accumulated school resources had a greater influence on students' academic success. By examining the contribution of these variables to the R^2 value of student achievement, the sub-study identified parents' highest educational level as the most significant determinant, surpassing other individual factors. The findings revealed that family support had a twice as significant impact on junior high students' academic achievement compared to school input. Furthermore, family support variables consistently demonstrated greater predictive power for students' educational outcomes across all models, outperforming school input variables. Through further analysis using quantile regression, it was observed that students with lower academic performance were particularly influenced by their parents' educational level and family cultural capital, rather than the educational level of their teachers. The fingdings underscore the prominent role of family support in determining students' academic achievements, emphasizing the significance of parental educational background and family cultural capital. The sub-study provides valuable insights into the relative importance of family support and school input, shedding light on the factors that have the greatest impact on student outcomes.

The *second* sub-study aimed to explore the independent role of effort as a predictor of academic achievement and its interaction with family socioeconomic status (SES). Despite the strong emphasis placed on academic success by Chinese families, there is limited research examining the relationship between effort and academic achievement, with educational disparities often attributed to structural and contextual factors, such as family SES. This sub-study utilized data from the China Education Panel Survey (CEPS 2013, 2014) to examine the influence of effort on educational outcomes and the interplay between effort and family SES. The results of the sub-study revealed that effort positively impacts academic performance, although to a lesser extent than family SES. Furthermore, the study found that students from low-SES backgrounds tend to exert more effort compared to their high-SES counterparts, and the effect of effort is more pronounced among low-SES students. These findings underscore the significance of individual effort in academic success, particularly among students from low-SES backgrounds. They also suggest that policies aimed at promoting academic achievement should focus on enhancing motivation and engagement to support students' efforts, especially for those facing socioeconomic disadvantages. By shedding light on the role of effort and its interaction with family SES in influencing academic outcomes, this sub-study provides valuable insights for researchers, policymakers, and educators. Recognizing the importance of individual effort alongside structural factors can contribute to the development of more comprehensive strategies to reduce educational disparities and foster equitable educational opportunities for all students.

The *third* sub-study aimed to enhance the prediction of students' academic outcomes by identifying more effective predictors or groups of predictors using machine learning techniques. This sub-study proposed that the efforts made by students, parents, and schools are interconnected and collectively contribute to determining academic achievements. Leveraging data from the China Education Panel Survey conducted between 2013 and 2015, this sub-study employed four widely used machine learning techniques, namely Lasso, Random Forest, AdaBoost, and Support Vector Regression, known for their

effectiveness in prediction tasks, to examine the predictive power of individual predictors and variable categories. The findings of this sub-study unveiled that the efforts exerted by each group have varying impacts on academic exam results, with parents' demanding requirements emerging as the most influential individual predictor of academic performance. Moreover, the study revealed that the category of school effort has a greater impact compared to parental and student effort when controlling for various social-origin-based characteristics. Additionally, the findings highlighted significant gender differences among Chinese junior high students, with school effort exhibiting a greater impact on academic achievement for girls, while parental effort showed a greater impact for boys. By contributing to the current understanding of the independent role of effort in the learning process, both theoretically and empirically, this study offers valuable insights. The findings have significant implications for education policies aimed at enhancing school effort, underscoring the need for gender-specific interventions to improve academic performance for all students.

In the concluding section of this thesis, a comprehensive discussion is presented that synthesizes the key findings from the three sub-studies and situates them within the broader research landscape of sociology, education, and psychology pertaining to the relationship between circumstances, effort, and academic achievements. The purpose of this discussion is to provide an overview of the existing knowledge in these fields and underscore the novel contributions of the present thesis. The discussion emphasizes the significance of the current research in advancing our understanding of educational inequality and offers insights for future research directions. By addressing gaps in the literature and shedding light on the interplay between circumstances, effort, and academic outcomes, this thesis lays the groundwork for further exploration and investigation in this important area. Furthermore, the findings of this thesis have practical implications for parents, schools, and policymakers in China. The discussion highlights the importance of collective effort, involving all stakeholders, in fostering improved academic performance for all students. It underscores the need for collaborative initiatives and

interventions that recognize the significance of circumstances and effort in narrowing educational disparities.

Key Words: Educational inequality, Academic achievement, Socioeconomic Status, Effort, Machine learning

Zusammenfassung

Die Frage, ob individuelle Anstrengungen den Defiziten in den Bildungsressourcen, die mit der familiären Herkunft einhergehen, entgegenwirken können, ist seit langem ein Thema in der akademischen Literatur. Frühe Arbeiten legten nahe, dass Unterschiede in den unternommenen Anstrengungen bestehende Ungleichheiten aufrechterhalten oder sogar verstärken können aufgrund eines bestimmten „Mittelklasse-Habitus" von Personen aus höheren sozioökonomischen Schichten. Jedoch argumentieren aktuellere Studien, dass erhöhte Anstrengungen die Nachteile der familiären Herkunft ausgleichen könnten oder sogar tatsächlich ausgleichen. Es ist weithin akzeptiert, dass ein Mehr an für das Lernen investierter Zeit und Energie den Leistungsunterschied zwischen Schüler:innen verringern kann. Trotzdem wurde den relativen Beiträgen von Anstrengungen und verschiedenen Kontextfaktoren zur Aufrechterhaltung, Verringerung oder Vergrößerung von Leistungsunterschieden bisher wenig Aufmerksamkeit geschenkt.

Im Bereich der Bildungsgleichheit gibt es umfangreiche empirische Belege dafür, dass die Schulleistungen durch ein komplexes Zusammenspiel verschiedener Faktoren beeinflusst werden. Insbesondere Faktoren des familiären und schulischen Umfelds der Schüler:innen sind eng mit den schulischen Leistungen verknüpft. Dazu gehört auch das Ausmaß der Anstrengungen der Schüler:innen, Eltern und Schulen. Darüber hinaus spielen die kognitiven Fähigkeiten und andere individuelle Faktoren, die als genetische Ausstattung betrachtet werden, nachweislich eine entscheidende Rolle für die schulischen Leistungen.

Trotz der Ausgereiftheit und des Umfangs der Forschung zu diesen Faktoren gibt es immer noch einen Mangel an Studien, insbesondere im chinesischen Kontext, die die relative Bedeutung dieser Faktoren für den schulischen Lernfortschritt von Schüler:innen und die Frage, wie die Faktoren

synergistisch Unterschiede in den schulischen Leistungen bewirken, umfassend untersuchen. Ausgehend von dieser Beobachtung ergibt sich die Frage: Inwieweit haben kontextuelle oder anstrengungsbezogene Faktoren wesentliche Auswirkungen auf die Schulleistungen, wenn der Einfluss angeborener Begabungen, wie z. B. der kognitiven Fähigkeiten, angemessen kontrolliert wird? Dabei ist es wichtig anzuerkennen, dass der sozioökonomische Hintergrund weiterhin implizite Einflüsse auf die schulische Leistung ausübt, was eine sorgfältige Berücksichtigung in der Analyse nahelegt.

Durch die Untersuchung dieser komplexen Dynamiken zielt diese Arbeit darauf ab, ein umfassendes Verständnis der Rolle von Anstrengung bei der Bildungsungleichheit zu gewinnen. Ziel ist es, die Zusammenhänge zwischen den Anstrengungen von Familien, Schulen und Schüler:innen und ihren jeweiligen Auswirkungen auf die Schulleistungen genau zu untersuchen. Um dieses Ziel zu erreichen, werden folgende Forschungsfragen gestellt:

1) Welchen relativen Beitrag leistet die familiäre Unterstützung im Vergleich zum Schulimput zur Beeinflussung der schulischen Leistungen der Schüler:innen?

2) Kann individuelle Anstrengung als unabhängige Variable, die zum akademischen Erfolg der Schüler:innen beiträgt, betrachtet werden, und wie variiert das Niveau an Anstrengung der Schüler:innen in verschiedenen sozioökonomischen Statusgruppen?

3) Wenn die Anstrengung einen eigenständigen Beitrag zur akademischen Leistung liefert, welche individuelle oder gruppenbezogene Variable im Zusammenhang mit den Anstrengungen von Schüler:innen, Eltern und Schulen ist dann am aussagekräftigsten für den akademischen Erfolg?

Um die oben genannten Forschungsfragen zu beantworten, werden in dieser Dissertation drei Teilstudien auf der Grundlage eines großen Paneldatensatzes aus China durchgeführt. Um

vorherzusagen, wo Leistungsunterschiede am wahrscheinlichsten auftreten, werden verschiedene Ansätze wie Relative Importance Analysis, Quantilregression und Machine-Learning-Techniken genutzt. Die Studie untersucht also potenzielle Prädiktoren, die zu ungleicher akademischer Leistung beitragen, und identifiziert so mögliche Hindernisse, auf die Schüler:innen der Mittelstufe im chinesischen Kontext stoßen können, sowohl unter Verwendung relativer als auch absoluter Variablenimportanz. Die Dissertation verwendet auch Machine-Learning-Regressionen wie Random Forest, Lasso, Adaboost und SVR, um die wichtigsten Merkmale zu extrahieren, die für die Bestimmung akademischer Leistungen entscheidend sind. Durch diese Analysen soll ein umfassenderes Verständnis der Faktoren vermittelt werden, die die Leistung von Schüler:innen in China beeinflussen, nicht zuletzt, um Politik und Praxis im Hinblick auf die Verringerung von Bildungsungleichheit zu informieren.

Hinsichtlich des Einflusses der kognitiven Fähigkeiten auf die Schulleistungen wird in dieser Arbeit ein umfassender Ansatz in allen drei Studien gewählt. In *Studie I* wird der Effekt angeborener Begabungen als eine geclusterte kontrollierte Variable behandelt, und sich auf den kombinierten Effekt von Geschlecht und den mit der familiären Herkunft verbundenen persönlichen Merkmalen konzentriert. Es ist wichtig zu beachten, dass dies ausdrücklich andere dispositionelle (genetische) Effekte ausschließt, wie z. B. nicht-kognitive und kognitive Fähigkeiten oder Talent. Darüber hinaus wird in *Studie II* und *Studie III* die kognitive Fähigkeit ausdrücklich als Kontrollvariable berücksichtigt. In beiden Studien wurden die Ergebnisse eines Tests der kognitiven Fähigkeiten verwendet, der Teil der chinesischen Paneldaten war. Dies ermöglicht eine genauere Untersuchung der Rolle der kognitiven Fähigkeiten und erhöht die allgemeine Gültigkeit und Zuverlässigkeit der Forschungsergebnisse.

Die *erste* Teilstudie dieser Arbeit hatte zum Ziel, den relativen Beitrag von familiärer Unterstützung und schulischen Ressourcen zur Bestimmung der akademischen Leistungen zu quantifizieren. Insbesondere sollte ermittelt werden, ob Schüler:innen mehr von familiärer Unterstützung oder von schulischen Ressourcen profitieren. Durch Analyse des relativen Beitrags dieser Variablen zum R^2 der

Schülerleistungen kam die Teilstudie zu dem Ergebnis, dass der höchste Bildungsabschluss der Eltern den signifikantesten Einfluss auf die akademischen Leistungen hat und damit andere Variablen übertrifft. Der Gesamteinfluss von familiärer Unterstützung auf die akademische Leistung von Schüler:innen der unteren Sekundarstufe war doppelt so signifikant wie der von schulischen Ressourcen. Darüber hinaus hatten familiäre Unterstützungsvariablen in allen Modellen durchweg eine höhere Vorhersagekraft für die Bildungsergebnisse der Schüler:innen als schulische Ressourcenvariablen. Eine weitere Analyse mittels Quantilregression ergab, dass Schüler:innen mit geringerer akademischer Leistung eher von dem Bildungsabschluss ihrer Eltern und dem kulturellen Kapital der Familie beeinflusst wurden als vom Bildungsabschluss ihrer Lehrer:innen.

Die *zweite* Teilstudie zielte darauf ab, die Rolle der Anstrengung als unabhängigen Prädiktor für akademische Leistungen und dessen Zusammenspiel mit dem familiären sozioökonomischen Status zu untersuchen. Trotz des hohen Werts, den chinesische Familien auf akademischen Erfolg legen, gibt es nur begrenzte Forschung zur Beziehung zwischen Anstrengung und akademischen Leistungen, und Unterschiede in der Anstrengung werden selten als bedeutender Beitrag zu Bildungsungleichheiten betrachtet, die in der Regel strukturellen und kontextuellen Faktoren wie dem familiären SES zugeschrieben werden. Diese Teilstudie verwendet Daten aus dem China Education Panel Survey (CEPS 2013, 2014), um die Auswirkungen von Anstrengung auf Bildungsergebnisse und die Interaktion zwischen Anstrengung und familiärem SES zu untersuchen. Die Ergebnisse zeigen, dass Anstrenung eine positive Wirkung auf akademische Leistungen hat, wenn auch in geringerem Maße als der familiäre SES. Darüber hinaus stellte die Studie fest, dass Schüler:innen mit niedrigem SES tendenziell mehr Anstrengung zeigen als Schüler:innen mit hohem SES und dass der Effekt der Anstrengung für Schüler:innen mit niedrigem SES größer ist. Diese Ergebnisse verdeutlichen die Bedeutung der individuellen Anstrengung für den akademischen Erfolg, insbesondere für Schüler:innen mit niedrigem

SES, und legen nahe, dass Politikmaßnahmen darauf abzielen sollten, Motivation und Engagement zu stärkenn, um akademische Leistungen zu fördern.

Die *dritte* Teilstudie konzentrierte sich darauf, bessere Prädiktoren oder Gruppen von Prädiktoren zu identifizieren, indem die Vorhersage der akademischen Leistungen mithilfe von Machine-Learning-Techniken verbessert wird. Diese Teilstudie postulierte, dass die Anstrengungen von Schüler:innen, Eltern und Schulen miteinander verwoben sind und gemeinsam die akademischen Leistungen der Schüler:innen bestimmen. Um diese Behauptung zu unterstützen, nutzte diese Teilstudie wieder die Daten aus dem China Education Panel Survey, das zwischen 2013 und 2015 durchgeführt wurde. Machine-Learning-Techniken dienten in dieser Teilstudie dazu, die Vorhersagekraft von einzelnen Prädiktoren und Variablenkategorien zu untersuchen. Die Ergebnisse zeigen, dass die Art der Bemühungen bzw. Anstrengungen, die von jeder Gruppe unternommen werden, unterschiedliche Auswirkungen auf die akademischen Leistungen hat. Insbesondere stellen sich das Vertrauen und die Erwartungen der Eltern an die Lernfähigkeit ihrer Kinder als die wichtigsten Prädiktoren für akademische Leistungen heraus. Darüber hinaus zeigt die Studie, dass Schul- und elterliche Anstrengungen größere Auswirkungen haben als die individuellen Anstrengungen der Schüler:innen und verschiedene sozialherkunftsbezogene Merkmale. Daher könnten direkte Interventionen, die verschiedene Arten von Anstrengungen beeinflussen, die akademischen Leistungen signifikant verbessern. Die Studie untersuchte die Rolle von Anstrengungen als unabhängigen Beitrag zum Lernprozess, sowohl theoretisch als auch empirisch. Sie deutet darauf hin, dass ein umfassender Ansatz, der darauf abzielt, Schüler:innen, Eltern und Schulen dabei zu helfen, verschiedene Anstrengungen zu unternehmen, die akademische Ergebnisse verbessern, wichtig ist.

Der abschließende Abschnitt dieser Arbeit widemet sich einer allgemeinen Diskussion der drei Teilstudien und bietet einen kurzen Überblick über Forschung in den Bereichen Soziologie und Lernpsychologie, die für die Beziehung zwischen Kontext, Anstrengung und akademischen Leistungen

relevant ist. Die Diskussion hebt hervor, wie die vorliegende Arbeit zur Erforschung der Bildungsungleichheit beitragen und neue Richtungen für zukünftige Studien aufzeigen kann. Darüber hinaus können die Ergebnisse der Arbeit Eltern, Schulen und politischen Entscheidungsträgern Informationen darüber liefern, wie wichtig kollektive Anstrengungen sind, um die akademischen Leistungen aller Schüler:innen in China zu verbessern. Abschließend wird auf die Bedeutung der Bekämpfung von Bildungsungleichheit und der Förderung gleicher Chancen hingewiesen, damit alle Schüler:innen ihr volles Potenzial erreichen können.

Schlüsselwörter: Bildungsungleichheit, akademische Leistungen, sozioökonomischer Status, Anstrengung, maschinelles Lernen

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1. General Introduction

Educational inequality is a highly significant topic in education research due to a strong correlation of academic attainment with social status that has been shown in different contexts. Ferreira and Gignoux (2011) have distinguished between two types of social inequality, along with corresponding measurement approaches: 1) Inequality of outcomes, evidenced by significant variability in outcome measures; and 2) Inequality of opportunity, identified by the extent to which one's intended outcomes are determined by family background and other predetermined personal characteristics, coupled with disparities in access to better-resourced schools.

This dual framework provides a useful foundation for exploring the multifaceted nature of educational inequality and the factors that contribute to it. Molina et al. (2013) furnish critical insights into the implications of educational inequality, highlighting that disparities in educational outcomes—when arising from inequitable opportunities, rather than individual effort or ability—can squander human potential and impede economic growth as well as institutional integrity. Building on this foundation, throughout this thesis, especially in the sections discussing empirical results, the terms "inequality" or "educational inequality" are intended to signify "inequality in educational outcomes arising from unequal opportunities." The aim is not restricted to examine the disparities in educational achievements that can be attributed to unequal access to resources, opportunities, and support, but also to inherent differences in individuals motivations, aspirations or specifically, effort levels.

This thesis is driven by two primary motivations. The foremost is Bourdieu's (1986) theory of cultural reproduction capital, which has sparked my interest. According to this theory, cultural capital is relatively consistent across various social groups, with differences primarily lying in the quantity of capital possessed. From this perspective, certain marginalized groups manage to achieve commendable

academic success by compensating for their lack of cultural capital (Kim et al., 2006). This notion raises important questions about the role of cultural resources in educational outcomes and how individuals navigate the constraints imposed by their social backgrounds.

The second motivation stems from Willis Paul's (1981) research on the perpetuation of social class among working-class students, with a specific emphasis on a subgroup known as the "lads." Willis's exploration delves into the manner in which these students forge a "counter school culture," a mechanism that continues the trajectory of their parents' social class via distinct cultural practices. However, an oversight in this research is its neglect of the cultural practices among another subgroup known as the "conformists"—students from working-class backgrounds who exhibit discipline and seriousness in their academic pursuits (Levinson & Holland, 1996). Therefore, a crucial area demanding attention is the developmental trajectory of the lower-class group, along with the factors contributing to their academic success. The investigation requires discerning whether their achievements should be attributed solely to the mechanical response of individuals to objective structures or whether subjective initiative and individual agency play a significant role.

In the Chinese context, a particular group of students from comparatively lower socioeconomic backgrounds has achieved remarkable academic success through an approach that sets them apart from their upper-middle-class counterparts (Yan & Gai, 2022). This group's accomplishments are particularly noteworthy in a society that highly values discipline and hard work (Huang & Gove, 2015). Unlike their more affluent peers who tend to perpetuate the social class of their parents through cultural practices, these students have taken advantage of educational opportunities to make significant strides on the socioeconomic ladder (Ling, 2015). Cheng and Kang (2016) argued that the concept of "underclass cultural capital" is instrumental in understanding their academic successes. Unlike Bourdieu's notion of cultural capital associated with the upper middle class, Cheng and Kang proposed that such a form of cultural capital is inherent to, and nurtured within, the underclass.

According to Cheng (2018), underclass cultural capital manifests itself in three distinct forms: an innate drive, a moral mindset, and schooled mental qualities. Firstly, the innate drive refers to a profound motivation to embrace education as a vehicle for altering one's fate. Individuals from disadvantaged backgrounds often harbor an intense aspiration to surmount their current conditions and aim for academic excellence. Secondly, the moral mindset perceives learning as a moral obligation or responsibility. Those endowed with underclass cultural capital regard education not merely as a path to personal advancement but as a moral endeavor that resonates with their core values and ethical obligations. Lastly, the schooled mental qualities encompass traits such as discipline and seriousness in study. Individuals possessing underclass cultural capital consistently exhibit a strong commitment to their education, marked by discipline and a concentrated study regimen.

Several scholars have supported Cheng's (2018) contention that the academic success of lower-class students is facilitated by the acquisition and utilization of specific forms of cultural capital endemic to the underclass (e.g., Cao & Zhu, 2021; Yu et al., 2022). However, there are also some researchers have challenged the notion of underclass cultural capital as being exclusive to this particular group (e.g., Hu & Wu, 2021; Zhang & Wang, 2021). They argued that the term "underclass" implies a lack of such capital within the upper-middle class, but in reality, this capital can be attributed to qualities such as perseverance, diligence, and meticulous study habits, which might transcend class boundaries. Capital itself represents a form of power or force, and its effectiveness is contingent upon the context in which it operates (Brown, 1995; Burt, 1997). In other words, it should not be viewed as static but as being sculpted by competitive environments.

While the underclass might indeed possess certain advantages derived from their cultural practices, it is crucial to recognize that these advantages may not necessarily be sought after by the middle and upper classes (Ball, 2004). Moreover, it is evident that the underclass often aspires to obtain the cultural capital inherent to the middle and upper classes. Therefore, the cultural capital of the underclass should

not be considered as a universally prevalent and circulating form of capital within the academic field (Yeoh, 2005). Instead, the concept of capital itself should be seen as the circulating entity (Lee & LiPuma, 2002). This contradictory rhetoric raises questions about the validity of the concept.

Therefore, rather than solely attributing the academic success of lower-class students to "underclass cultural capital" from a sociological standpoint, this thesis adopts a psychological perspective that emphasizes the concept of "effort." It argues that the remarkable achievements of these students can be attributed to both objectively measurable efforts, such as the time and energy they dedicate to the learning process, and subjectively perceived efforts (Steele, 2020). These subjective efforts encompass their deep sense of gratitude towards their parents, their aspirations for changing their own destiny, their personal determination and agency, and the value they place on recognizing their self-perceived significant effort (Wang, 2020; Shain, 2021).

Through a psychological lens, this thesis aims to illuminate the multifaceted factors that drive the academic achievements of lower-class students. While it acknowledges the undeniable influence of cultural capital (as well as other capitals), it posits that the concept of effort captures a broader range of psychological and motivational determinants. By examining the various dimensions of effort and inevitable contextual factors, this thesis strives to provide a comprehensive understanding of the mechanisms underlying the achievements of lower-class students, highlighting the importance and the recognition of being effortful.

Over the years, scholarly research has delved into a plethora of factors that impact student achievements and outcomes. Boyd (2009) investigates the influence of social background on the educational and vocational successes of immigrants' offspring in Canada. Buchmann (2002) emphasizes how disparities in household resources contribute to academic achievement gaps among children. Coleman's (1988) seminal work, along with Lareau's (2011) studies, deepen our comprehension of how

familial capital and school efficacy contribute to the perpetuation of academic benefits. Concurrently, the theoretical constructs of social status attainment and self-determination theory, as discussed by Zimmerman (1989) and Eccles (1994, 2005), assert the centrality of academic self-efficacy beliefs and self-regulatory processes. This body of work aligns with the hierarchical model of achievement motivation, elucidated by Cury et al. (2006), demonstrating the significant influence of psychological and behavioral efforts on educational attainment. Complementing this perspective, Lushyn et al. (2020) highlight the critical role of social psychological factors in shaping educational trajectories.

Ideally, achievement gaps between students should only reflect variations in individual capabilities (Broer et al., 2019). Without taking into account the role of effort, such gaps may be attributed solely to distinct circumstances students encounter. This can result in inaccurate diagnoses of educational inequalities and ineffective policy solutions. Consequently, this thesis emphasizes the dynamic interplay between circumstantial factors and individual efforts in shaping educational outcomes, with a specific focus on the role of effort. It is vital to acknowledge that this research centers around educational outcome inequalities observed in the context of the China Education Panel Survey (CEPS). The pivotal inquiry it seeks to resolve is: How do individuals from disadvantaged backgrounds achieve noteworthy academic success?

However, predicting the factors that contribute to disparities in learning outcomes is a complex task, as it requires considering the specific contextual factors within each educational system. These influential variables can vary based on a society's historical and societal backdrop. Pertaining to China, significant achievement gaps are associated with various fundamental background characteristics, including family economic capital, school resources, gender, and rural/urban residence status (e.g., Israel et al., 2001; Roscigno et al., 2006; Wu, 2011). The prevailing discourse on educational inequality in China has paid limited attention to the role of effort as a separate input to the educational trajectory, both theoretically and empirically. The primary debate within the Chinese context primarily revolves around

the influence of family backgrounds, parental involvement, school differences, or regional resource allocation on educational outcomes among junior high school students, while the role of effort has been largely overlooked.

To address this research gap, this thesis employs data from the China Education Panel Survey (CEPS). The CEPS dataset is a comprehensive and extensive collection that provides detailed background information from various sources including parents, students, teachers, and school principals. Additionally, it includes achievement data collated over a span of three years. Leveraging this extensive database, the thesis endeavors to identify the most significant predictive factors contributing to educational inequality through three distinct sub-studies.

These sub-studies will delve into the multifaceted relationship between effort and educational outcomes, exploring how disparate levels of effort interact with other contextual factors to shape student achievement. Undertaking rigorous analyses of this complex interplay, the thesis seeks to unveil the key determinants of educational inequality in China. Moreover, deriving from the revelations of these analyses, the thesis will propose effective approaches and empirically-grounded strategies to address and mitigate these disparities.

The thesis is structured as follows: Section 2 introduces the theoretical framework that underpins the research. Section 3 outlines the conceptual framework employed in the three sub-studies. Section 4 encompasses the general discussion, which offers a comprehensive overview of the research findings, their theoretical and practical implications, the limitations encountered, and potential avenues for future research. The Appendix includes three specific studies aimed at addressing academic underperformance among Chinese junior high students.

2. Theoretical Framework

2.1. Evolving Educational Inequalities Driven by Social Disparities

Education is a multifaceted concept that not only has intrinsic value in enabling a high level of development of human nature, but also serves as a critical vehicle for individuals to pursue other values (Niemiec & Ryan, 2009). Theoretical discourses on social inequality suggest that education is a preparatory arena for individuals to engage in a market economy and secure additioanl social achievements (Lynch, 2000; Brighouse & Swift, 2009). Empirical research has corroborated a favorable linkage between educational outcomes and prospective socioeconomic achievements and status (Caro et al., 2009; Ahmar & Anwar, 2013). However, unequal distribution of educational resources can significantly impact an individual's competitiveness in the labor market. This dynamic has propelled sociologists to stress the importance of competitive equality, which advocates that educational outcomes should not be influenced by factors beyond an individual's control (Brighouse, 2000). Ideally, an individual's vision of educational opportunities and outcomes should rely on their "talent" and "effort" rather than predetermined social strata or familial lineage (Roemer, 1998). Following the the principles of compensation and liberal reward, it is advocated that educational resources be allocated fairly, recognizing an individual's intellectual abilities and the diligent effort they invest in cultivating their skills, irrespective of their socio-economic origins (Fleurbaey, 2008).

However, despite the ideal of competitive equality, an inequitable allocation of educational resources persists, resulting in social class and family background influencing educational opportunities and outcomes (Roemer, 1998; Barry, 2005). The intricate interplay between social inequalities and educational outcomes has been extensively studied in sociology and education, with traditional approaches relying on the well-known cultural capital reproduction theory. This theory posits that education perpetuates the existing social structures, reproducing the dominant culture and values that

favor the interests of those in positions of power and privilege (Bourdieu & Passeron, 1977). In the Chinese context, scholarly endeavors have sought to dissect the factors and mechanisms that generate inequality in educational outcomes and the ways in which social inequalities either reduce or exacerbate this inequality. In the following section, I will review these studies and discuss their findings.

2.1.1.   *Industrialization Hypothesis: Educational Expansion as a Determinant*

In industrialized societies, the occupation has been established as a key stratification system, given the highly specialized and divided labor markets. Such a perspective contends that an individual's occupation primarily shapes their socioeconomic status, wherein education acts as a critical factor in acquiring desired occupational roles (Buchmann & Hannum, 2001). Due to the demand for specialized skills in these societies, certain occupational positions necessitate individuals endowed with professional knowledge and specialized skills, which are typically acquired through systematic education and training (Scott, 2008; Robles, 2012). The expansion of education at all levels during the first half of the 20th century accompanied the acceleration of the industrialization process. This underscored the exigency for egalitarian educational avenues, ensuring individuals are equipped with the requisite knowledge and competencies to vie for coveted occupational positions.

The expansion of educational frameworks across all levels has led to the formation of a stratified system that allocates a large number of educated employees to different jobs through screening mechanisms that are differentiated. Therefore, access to educational opportunities is more dependent on individual diligence and talent than on family background (Macleod, 2010; Calvert, 2015). In essence, augmenting the educational spectrum across multiple stages promotes an even distribution of educational resources where all groups can benefit, and consequently, engendering equal educational outcomes. Hauser and Featherman (1976) have supported these findings with extensive survey data and empirical research.

Mare (1981), however, identified gaps in extant research. He noted that statistical modeling should incorporate confounding factors, which might not accurately reflect previous findings, such as the effect of the marginal distribution of education levels across age groups. Mare argued that the impact of family background on educational opportunity and outcomes has increased rather than decreased. This assertion is consistent with the Coleman Report—formally known as the *Equality of Opportunity in Education Report*—published in 1966. The report accentuated that achieving equality of opportunity in education should also aim at achieving equality of outcomes. Inequitable access to school resources, largely determined by family economic status, has resulted in widening disparities in student achievement. The Coleman Report's findings have then been validated by subsequent research from various perspectives and expanded into different insights.

In essence, the root causes of educational disparities are not anchored solely in personal merits, such as ability and effort. They also find footing in social antecedents like family economic background, a factor that remains steadfastly influential. Despite the acceleration of industrial processes and the expansion of education, complete equality in education remains elusive, and educational stratification persists (e.g., Ballarino et al., 2009). The socially advantaged classes continue to enjoy enhanced access to educational prospects, reaping superior outcomes, owing to their pre-existing superior resources, notably their elevated socioeconomic status.

2.1.2.   Cultural Capital Reproduction Theory: Maintaining the Dominant Class Status

This thesis recognizes the unequal nature of educational outcomes and seeks to examine the mechanisms that perpetuate inequalities in education. Specifically, this section investigates how family socioeconomic status and various capitals enable the maintenance of dominant positions in educational attainment through their influence on individual academic achievement. The Reproduction Theory, a widely accepted concept, posits that education serves as a screening mechanism, maintaining the

dominance of higher social classes while marginalizing middle and lower socioeconomic strata (Bourdieu, 1973; Laumann & Senter, 1976; Nash, 1990).

According to the reproduction theory, socially privileged groups or classes furnish their children with superior resources, both via structured systems and alternative avenues. These resources, in turn, provide sustained support throughout the education process, increasing their prospects of academic success. This phenomenon has been extensively studied in the literature (Brubaker, 1985; Lamont & Lareau, 1988), and is seen as a key mechanism in the transmission of professional interests and capital. Reproduction theory sees education as a fertile ground where these mechanisms are disseminated and converted. This theoretical paradigm forms the bedrock of the dissertation at hand.

2.1.2.1.   *Underclass Cultural Capital Reproduction*

Cultural capital plays a more insidious role than other forms of capitals in shaping educational outcomes. Instead of attributing these outcomes merely to individual effort, Bourdieu's theory of cultural capital reproduction explains disparities in educational attainment to the uneven unequal distribution of cultural capital across various social classes (Bourdieu, 1973, 1977). Analogous to other mechanisms that generate and recycle resources, a mutually reinforcing relationship exists between the cultural capital families possess and the educational system, particularly evident at the primary school level. In other words, students' educational outcomes are influenced by the cultural capital that their families have invested in education. As these students embark on the educational and training process, the family's cultural capital is manifested institutionally through academic credentials and other representational forms. Acknowledging the intergenerational transmission of cultural capital, the educational system can reinforce and reproduce societal hierarchies.

Bourdieu (1977) emphasized that academic disparities among students are often conveyed by their living and thinking habits, ability to adapt, and perceptions of the external world, all of which are molded by their familial backgrounds. Distinctive family cultures can profoundly influence academic outcome disparities (Sullivan, 2002). In contrast, achieving equal educational outcomes during school life proves more challenging. For the lower and middle classes, assimilating elite culture from school demands substantial sacrifices, encompassing overcoming formidable barriers. For the upper classes, however, this culture is simply an inherited privilege (Bourdieu, 2002). For academically underserved individuals, schools represent the sole avenue for cultural acquisition. The restrictiveness of this cultural acquisition is mirrored throughout all stages of education, contributing to a wide range of inequalities. Such barriers not only contribute to the achievement gap associated with social class but also reinforce educational disparities (Stephens et al., 2012). Unlike human capital, which can fluctuate with changing circumstances, cultural capital tends to be a more enduring and inheritable asset. It is integral to the success of students within the educational system and acts as a cornerstone of educational inequality, further entrenching societal divisions.

The broader understanding of cultural capital acknowledges that children from lower social classes may initially lack innate cultivation of such cultural capital, but they have the capacity to acquire it through subsequent processes, including schooling and intentional familial instruction that aligns with the educational system (e.g., Farkas, 2018). Even as it acknowledges the class-based nature of cultural capital, this perspective challenges the class boundaries of cultural capital, opposes its exclusive appropriation by the middle and upper classes, and promotes a closer relationship between the underclass and cultural capital. Cheng and Kang (2016) then raised an important question: "Can the cultural capital that contributes to the academic success of underclass children only be transplanted? Don't underclass children possess their own inherent cultural capital?"

In further exploration, Cheng (2018) classified "underclass cultural capital" as "physical cultural capital," encompassing the support and academic assistance provided by teachers, resources like books, and a myriad of intellectual strategies, habits, and styles that are compatible with social institutions. Such underclass cultural capital has proven instrumental in realizing top-tier academic results among underclass children within educational settings (Lan, 2014). Additionally, underclass cultural capital is closely tied to individual initiative. Individuals can be motivated to activate the relevant cultural capital, gaining a deeper insight into the underlying cultural capital that can be translated into academic success (Liu, 2016).

In line with Cheng's (2018) definition and understanding of "underclass cultural capital," the dispositions such as independence, hard work, perseverance, self-discipline, responsibility, and other traits that meet schooling prerequisites are precisely the habits that are compatible with the current basic education field in China. Such habits become deeply ingrained in students' routines. Studies reveal that China's elementary education system primarily relies on objective examinations, with regular and competitive test scores serving as the main criteria for evaluating educational achievement (Tan, 2016).

In such an educational field, a learning style focused on repetition, rote memorization, and substantial time commitment tends to benefit learners in securing higher achievements (Kember, 2016). Consequently, in a system where assessment and evaluation are objective and standardized, the significance of cultural capital as "refined culture" diminishes in the mainstream perception. Simultaneously, the emphasis on students' cognitive abilities and personal efforts becomes more pronounced (Zhang, 2005). Such a landscape provides an opportunity for children from economically constrained families to develop the cultural capital necessary for successful learning at a lower cost in terms of family instrumental time and financial resources (Lin, 2019). As a result, children from these disadvantaged backgrounds gain the opportunity to acquire the habits and skills needed to navigate the learning process more effectively.

In essence, the habits fitting the prevailing Chinese elementary education context are not exclusive to a particular social class. The development of these habits is not solely influenced by the specific circumstances or cultural practices of the underprivileged. Rather, it is primarily because the requirements for cultivating these habits are relatively attainable for a wider range of individuals. Every family, along with their children, has distinct perceptions, attitudes, and interpretations associated with schooling, shaped by their socio-economic status and historical experiences (Fung et al., 2017). These differences contribute to the perception of schooling as an "academic game." Research indicates that rural university students prioritize academic achievement over participation in semi-official student organizations like student unions (Xie, 2022). On the other hand, those from affluent backgrounds, benefiting from their families' socio-economic capital, may display a tendency to prioritize extracurricular activities, adeptly manipulating their cultural capital to excel in areas such as student leadership roles and English proficiency scores (Zhou & Kim, 2006).

Families belonging to the middle and upper classes often value their children's academic performance. However, they are less likely to associate schooling with notions of social mobility or changing their destiny (Howlett, 2017). In china, it is primarily families from the lower socioeconomic strata who possess an inherent aspiration to defy their circumstances and harbor moralized beliefs about the transformative power of education (Leung, 2010). Yet, these concepts, arising from the relational dynamics within a particular social context, are specific to the underclass and are not universally ingrained. Hence, this subjective motivation towards schooling, unique to the underclass, can appear more like an "illusion" (e.g., Tian, 2019).

When examining the three aspects of "underclass cultural capital" within Bourdieu's field theory, it becomes evident that the dispositions developed by underclass children to adapt to schooling resonate with Bourdieu's notion of "habitus" (Ingram, 2009). The effectiveness of "underclass cultural capital" within a specific institutional context and interaction structure implies that the "underclass" excel at

"playing the learning game" within the current educational system (Wong & Liao, 2022). This infers that they have cultivated habits that are suitable for this game, either inherited from their original family field or shaped through their engagement with the educational field (Chen & Tian, 2021). However, the positive attitudes and meaningful experiences they have towards schooling may be perceived as mere "illusions". Accordingly, Zhu (2022) advocates for "compensatory strategy" as a term that more accurately reflects the inherent challenges and the intentional mobilization of cultural resources by individuals in adverse circumstances. This reconceptualization critiques that the term "underclass cultural capital" inadvertently endorses the norms of elite culture and overlooks the intricate power dynamics within the cultural landscape.

Furthermore, the process of self-accumulation of cultural capital necessitates an initial "start-up capital." It is crucial to recognize that individuals endowed with at least a minimum level of economic and cultural resources, which grants them some degree of power over the mechanisms they are expected to navigate, can effectively conform to the implicit demands of the economic landscape (Davies & Rizk, 2018). For Chinese students, their dispositional tendencies to adapt to the schooling system fulfill this requirement, constituting a form of "embodied cultural capital" (Hu & Wu, 2021). Nevertheless, it is crucial to emphasize that this capital is not exclusive to any particular context. Its existence simply implies that students from less privileged backgrounds possess the minimum qualifications necessary to participate in the educational system, but it does not guarantee academic success (Gao, 2011).

To summarize, Cheng and Kang's (2016) conceptualization of "underclass cultural capital" suggests that the inherent tendency to adapt to schooling aligns with Bourdieu's notion of "habitus" and is compatible with the current landscape of China's foundational education. On the other hand, the positive attitude towards schooling and the perception of its significance fall into the realm of what Bourdieu would consider as an "illusion" (e.g., Tian, 2019). The former, serving as a form of "start-up capital" and thus applicable universally, can be classified as embodied cultural capital. The latter,

however, holds significance primarily in a distinct context, paving the way for educational opportunities for children of the underclass.

The indiscriminate inclusion of these various aspects under the umbrella term of bodily cultural capital as a habitual practice, and the labeling of "illusion" as a form of "capital," represents a potential conceptual misapplication (Jin & Ball, 2020). This misapplication results in linking the cultural capital possessed by underclass children with the unique nature or intrinsic worth of the underclass situation itself (Joyce & Edinboro, 2022). Even if one leans towards a more encompassing interpretation of Bourdieu's concept of cultural capital or habitus, it might still invite a possible "deficient" practice of educating the working class families.

Therefore, this thesis argues that instead of solely attributing that the humble situation itself inherently contains certain cultural capital with humble characteristics fueling students' motivation to achieve educational success (Manstead, 2018), it is worth considering the impact of an individual's internal drive to overcome adversity from a psychological perspective. Notably, the societal stigma associated with being at the bottom of the social hierarchy instills a strong and enduring inner drive to strive for upward mobility (Lucas, 2011; Stephens et al., 2014). Students hailing from lower-class backgrounds demonstrate behavioral and psychological efforts, compelling them to take control of their time, engage in intellectual pursuits, and develop societal empathy (Yee, 2016). These factors significantly contribute to their determination to transcend their social class and realize academic success.

2.1.2.2. *Human and Social Capital Reproduction*

The theory of human capital reproduction, another subcategory of reproduction theory, provides an explanation for the perpetuation of educational inequality. According to this theory, education is perceived as a form of human capital investment (Becker, 1962). Guided by the principles of economic

cost-benefit analysis and maximization of interests, households with ample economic resources are more likely to invest more heavily in their children's learning process. This typically results in higher educational success. In contrast, while children from low-income families are more likely to experience limited educational investment, leading to comparatively lower educational outcomes (Longo et al., 2017). This dynamic perpetuates the socioeconomic hierarchy, as advantaged families use their resources to ensure their children's success in the educational arena, thus maintaining their dominant positions in society (Von Otter & Stenberg, 2015).

Furthermore, the reproduction of human capital investment operates through the medium and expression of diplomas or educational qualifications. The middle and upper classes must first dominate in education sphere if they want to maintain their privileged position in the future labor market (Paulsen, 2001). Employers allocate positions in the labor market to employees based on their academic credentials, and educational outcomes thus serving as a final representation of previous investment values in human capital (Walters, 2004). As a result, the acquisition of academic success is inextricably linked to one's family background and the extent of household investments in human capital (Novelli, 2016).

Additionally, the social capital theory highlights the impact of parental involvement on students' academic performance across various socioeconomic backgrounds. Parents of higher socioeconomic status are typically more innvloved in their children's learning activities. They are better equipped to interact with school teachers and other parents and have greater resources to participate in schooling. This involvement leads to positive effects on their children's learning behaviors and educational outcomes (Bourdieu, 1986; Coleman 1988). Conversely, parents from lower socioeconomic backgrounds, hindered by barriers like lack of engagement abilities, fear of rejection and criticism, and logistical challenges like time constraints and distance, are more likely to view education as the sole responsibility of schools or teachers, rather than a shared duty. Such parental absence from the

educational process can result in diminished engagement and have an unproductive or even negative impact on students' academic achievements (Portes et al., 2005).

In general, existing research findings indicate that the factors contributing to unequal educational outcomes are multidimensional and complex. Aspects such as socioeconomic status, school resources, diverse family capitals, and the motivation to learn have been extensively studied in the academic literature. The roots of educational inequality extend beyond a handful of elements, with multiple factors interacting within a systematic framework. It is therefore crucial to analyze high-dimensional data that encompasses a broad range of influencing factors in order to derive more accurate and unbiased empirical conclusions.

2.2. Potential Factors Contributing to Unequal Educational Outcomes in the Chinese Context

2.2.1.   The Impact of Socioeconomic Disparities on Educational Choice

The reproduction of social class is not only influenced by socioeconomic resources but also by how families exploit them, manifesting in various cultural systems. In France, where cultural selectivity is highly valued, cultural capital plays a major role in shaping educational outcomes (Brown et al., 2016). Conversely, South Korea tends to emphasize market-based competition and selection, viewing extracurricular remediation as an advantageous option to bridge achievement gaps (Lee & Shouse, 2011). Although Boudon (1974, 1998, 2003) maintained that both primary and secondary effects help perpetuate structural inequalities between classes, he also extolled the virtues of secondary effects. He argued that even when students from different classes achieve the same level of attainment, their subjective family choices in education will differ due to varying preferences, perceived costs, risks, and benefits. Therefore, the significance of familial decision-making aptitudes and coping strategies in this reproductive mechanism cannot be understated.

Determinants of educational outcomes are complex and multifaceted, extending beyond simple conceptual frameworks that emerge from background circumstances, subjective educational choices, or strategic actions developed by families or individuals at the micro-level. The dynamic role families play in shaping educational outcomes deserves additional attention. Divergent educational interventions, such as family expenditures, expectations, and schemes in education, reflect diverse education outlooks and outcomes from the family' standpoint (e.g., Becker, 2003; Croll, 2004). The family context exerts an objective influence, correlating with students' academic success through the family unit's subjective willingness to education (Hu & Hossler, 2000). It has been argued that individual educational outcomes are essentially a process of decision-making and behavioral choice by the family after rational reflection. One of the underlying determinants of educational inequality is the disparity in subjective educational aspirations across classes, which can amplify and solidify socioeconomic and cultural differences in academic achievement (Cheadle, 2008; Attanasio & Kaufmann, 2009).

Educational inequality has garnered increasing attention among Chinese scholars in recent years. Macro-level social transformations has brought about significant changes in the factors that generate disparities in education outcomes (Yang et al., 2014). While international studies are broader in scope, research on China's educational inequality is more localized, reflecting the country's unique economic and social contexts. One of the primary factors that contribute to disparities in educational outcomes in China is socioeconomic status. Changes in socioeconomic status differently influence the educational choices of low-SES and high-SES families. For instance, due to the increased cost of tertiary education and the challenges faced by college graduates in securing employment, lower-SES families often lean towards early labor market entry rather than further education investment. This highlights how limited socioeconomic resources adversely impact disadvantaged households, while having minimal impact on higher-SES families who can afford to invest more in their children's education, thereby obtaining more competitive academic qualifications (Kim et al., 2019; Liu et al., 2020).

The declining relative opportunities for low-SES students to access university has attracted much attention in China. However, Chun-Ling (2015) suggested that the roots of these disparities might trace back to the transition from middle school to high school. During this period, families' differential decision-making can set students on divergent paths, ultimately influencing university access and future career prospects. Tang (2016) similarly highlighted secondary education as a key source of educational inequality. He argued that the educational choices made by families critically impact students' future opportunities. This suggests that there is a path dependency and cumulative impact within educational progress, whereby different quality of educational outcomes over the three to six years leading up to university can compound the effects of unequal access (Wu, 2010). Guo (2015) further underscored the importance of the transition from junior high to high school as a central research point in the Chinese context and a critical node in its educational stratification.

As research on educational inequality in China progresses, scholars have sought to link inequalities in the compulsory education stage (grades 1-9) to broader social stratification. Educational inequality becomes apparent early in secondary education, particularly during the junior high school years, due to a series of screening processes that occur from admission exam to graduation exam, ordinary class to outstanding class, and, ultimately, from progression to higher education (Hannum, 2003, 2005). Each selection depends on prior educational outcomes, which can either enhance or diminish opportunities for students to progress in their education and future academic pursuits (Bian, 2002; Yeung, 2013). However, the specific phenomenon and original causes of educational inequality during this critical period remain underexplored. This study posits the junior high school phase as an overlooked, yet crucial, stratification juncture in educational inequality. Disparities arising during this stage, catalyzed by family educational choices based on socioeconomic standing, have rarely been delved into or empirically substantiated. To address this research gap, this thesis uses data from the China Education Panel Survey (CEPS), which provides comprehensive information on secondary education in China, to extensively

investigate Chinese junior high school students' educational choices, school preferences, learning developments and dilemmas.

2.2.2.   The Impact of Key School Systems on Systemic Segregation

The Key School System has been a dominant thread in the Chinese educational regime, serving as a crucial factor in determining students' access to high-quality educational outcomes (Tsang, 2000). More recent research argues that the divergence of key and non-key school pathways at the secondary education stage has resulted in significant educational stratification and differentiation in Chinese society. This divergence significantly impacts an individual's future career attainment (Ye, 2015). Historically, the Key School System was established due to the Chinese government's strategic planning for accelerated education reform. Its primary objective was to consolidate the then sparse and disparate educational resources to rapidly cultivate a large number of professionals and technicians required for industrialization and urbanization. Over time, the system transitioned from a deliberate, scheduled government intervention into a fixed, institutionalized education system. It undeniably facilitated the expansion of public schools and compulsory education during its early stages (Li & Xue, 2021).

By 1962, public schools in China were formally categorized into key and non-key schools, with the aim of improving the education system's efficiency in generating human capital. However, this division has been criticized for jeopardizing the population's right to equitable education. s key schools emerged as elite institutions, the education landscape became increasingly polarized (Bian, 2002; Guan, 2005). By the late 1990s, these key schools failed to achieve their primary objective of fostering the development of public schooling and equal opportunities. In response to the deepening educational segregation, the new Compulsory Education Law of 2006 was enacted, proscribing the labeling of schools as key or non-key (Bao, 2006). Nevertheless, the legacy of this system persists. Although the clear-cut classification has diminished, distinctions now often manifest under the guise of "model

schools." The surge in demand for educational resources, coupled with escalating competition, has only exacerbated this division (You, 2007; Liu & Apple, 2016).

The impact of the key secondary school system on educational polarization has been a topic of extensive debate. The prevailing viewpoint suggests that the system exacerbates pre-existing inequalities, particularly between urban and rural areas and among different socioeconomic groups (Ngok, 2017). Studies show that students hailing from higher-income urban families tend to attend key secondary schools, while those from lower-income rural families are inclined towards non-key schools (Yang, 2005). Furthermore, the key school system appears to worsen social class, educational, regional, and urban-rural disparities across China (Lai et al., 2016). However, some studies present a more nuanced view. For instance, Liang et al. (2012), based on their comparison of 150,000 undergraduates, found that certain key secondary schools, especially county key schools, can help reduce the urban-rural education gap by providing quality education to some outstanding rural students. Yuxiao and Chao (2017) argued that family socioeconomic status strongly influences children's educational outcomes, its influence is mainly indirect—stemming from the institutional arrangements set by the dominant class, which in turn guides their offspring's enrollment in key schools.

Furthermore, several scholars have pointed out that significant achievement gaps exist within key schools. Wu (2012) and Chen and Feng (2013) argued that privileged students from the higher social classes have a better chance of accessing key schools and subsequently securing more favorable educational outcomes due to their economic and cultural advantages. Therefore, rather than serving as conduits bridging students from diverse familial and regional backgrounds, the key school system might exacerbate institutional exclusions. In light of these observations, this thesis seeks to examine not only how family backgrounds shape educational outcomes but also how schools themselves perpetuate these outcome inequalities.

2.2.3.   The Significance of Effort in Addressing Educational Inequalities in China

2.2.3.1.   The Definition, Measurement, and Importance of Effort

While structural and contextual factors are widely acknowledged as key determinants of individual status attainment and social differentiation, the role of individual agency and effort cannot be underestimated. A wealth of literature has examined family background differences and systemic structural factors (e.g., Heckman, 2011; Kim et al., 2018). However, these factors alone fail to account for the heterogeneity of social and academic status acquisition. It is increasingly understood that differences in academic achievement persist even among individuals with identical family backgrounds and schooling (Egalite et al., 2016). Social differentiation is not solely caused by objective factors such as family background. Subjective dynamics, such as individual effort, also play a pivotal role and shouldn't be dismissed (Claro et al., 2016; Alhadabi & Karpinski, 2020).

Effort is proven to influence how individuals approach education at large, how they respond to classroom interactions with teachers, how much time and motivation they dedicate to learning, how much assistance they receive from family, how they carry out the necessary tests, and some other academic needs in all stages of education (Inzlicht et al., 2018). It is challenging, if not inconceivable, to enhance students' educational success if they do not employ effort, regardless of their family background or school quality (Dweck, 2002). Additionally, students who don't put in the necessary effort can inadvertently disengage both themselves and their peers from academic pursuits, potentially impacting the broader classroom or school atmosphere (Carini et al., 2006).

Effort is a vital aspect of academic success, however, it can be challenging to measure due to its subjective nature. The process of committing one's physical and mental energy to achieving a goal is difficult to quantify (Kurzban et al., 2014). Self-determination theory is the most relevant theory for understanding effort. As a macro theory of human motivation, it has been successfully applied across

various domains, including parenting, education, healthcare, sports and physical activity, psychotherapy, virtual worlds, work motivation, and management (Deci et al., 2001; Ryan & Deci, 2017).

According to self-determination theory, intrinsic motivation is a crucial resource that individuals can utilize to achieve their goals. Intrinsic motivation refers to behaviors that are inherently interesting and enjoyable and done without external influence (Ryan & Deci, 2000). The theory posits that intrinsic motivation can be sustained by satisfying the basic psychological needs of competence or effectance (e.g., White, 1959), relatedness or belongingness (e.g., Baumeister & Leary, 1995), and autonomy or self-efficacy (e.g., Decharms & Carpenter, 1968).

Following self-determination theory, effort is perceived as a subjective experience, entailing the pursuit of demanding tasks that require executive functions, thereby allowing individuals to exercise self-control during effortful tasks (Levi et al., 2014). Within the realm of psychology, effort is linked to self-management, conscientiousness, and grit, which are important determinants of life outcomes (Almlund et al., 2011; Borghans et al., 2011). In educational research, effort is commonly understood as the commitment to utilizing physical and mental energy to achieve a certain goal or result, often measured through metrics such as time spent on homework (e.g., Trautwein, 2007). However, Sherwood (2016) suggested that effort should be characterized by both its quantity and its quality, reflecting not just the intention to act but also the ability to act.

By differentiating effort into two distinct forms: objective effort and subjective effort, Steele (2020) provided a clear definition on the concept of effort during task performance and encouraged a common understanding across various disciplines. Steele (2020) posited that "objective effort" encapsulates tangible, measurable actions denoting the amount of energy or work invested in a task. Examples include the number of hours spent studying, the number of assignments completed, or scores on standardized tests of particular knowledge and skills to be learned or trained. Conversely, "subjective effort" captures

the intangible and internal experiences and attitudes related to a task or goal, such as self-efficacy, goal orientation, and, fittingly, intrinsic motivation.

This thesis builds upon Steele's (2020) conceptualization of effort, which encompasses a wide range of factors that influence how students approach education. The "student effort" include their responses to classroom interactions with teachers, the amount of time and motivation they dedicate to learning, the level of inspiration they receive from their families, their performance on necessary tests, and other commitments they make to fufill academic needs throughout their education (Dunlosky et al., 2020, Mudrak et al., 2021).

This thesis also acknowledges the role of parents and schools as behavioral agents and recognizes the importance of their effort in promoting student academic achievement. The effort of parents and schools goes beyond mere educational investment behavior; it also an inherent conviction that kindles motivation, channels psychological focus, and entails an augmented investment of time and vitality to enhance students' academic endeavors (Ng, F. F. Y., & Wei, 2020). This approach allows for a holistic view of the role of effort and facilitates a better understanding of potential academic obstacles and successes by providing a more comprehensive assessment of both the amount of energy or work invested in schooling and the students' internal experiences and associated attitudes.

2.2.3.2. Research Gap: The Missing Role of Efforts in The Chinese Context

In the Chinese context, among the most nonnegligible facets, the intense integration with socioeconomic backgrounds and policy-based school systems is a prominent feature of educational inequality research (Liu et al., 2020). Horizontally, the specific geographical distinction of China, characterized by its urban-rural dualistic distribution, has garnered attention. Vertically, research has primarily examined the socioeconomic disparities between rural and urban families (Koo, 2012; Ma et al., 2018). This urban-

rural dualistic structure has led researchers to probe the inheritance of characteristics and resources within families. Simultaneously, variations within and between social classes have directed researchers to delve into the transformation between family background and opportunity and outcome in education amid urbanization (Pan, 2018). In resource allocation, the family and school resources are the two fundamental forces determining how students' total educational resources are allocated and thus hinder students from equal access to and outcomes in education (Du & Hu, 2008; Yu & Ding, 2011; Fan, 2014).

While extensive research over the last two decades has provided a comprehensive understanding of social inequalities and changes in China's education sector (Rong & Shi, 2001; Cheng, 2009; Wu & Zhang, 2010; Knight et al., 2013; Wu, 2018; Ma et al., 2018; Guo et al., 2019; Ma & Wu, 2019), a gap in the literature regarding the role of effort in shaping educational outcomes in the Chinese context. Although the measurement and discussion of effort-based outcomes is a fundamental criterion for assessing equality, this area has been underrepresented in prior studies. Often, research has conflated educational inequalities with student effort differentiation. This amalgamation has led to an inadvertent disregard for the impact of effort factors on students' educational outcomes. Liu (2015) stands out as one of the limited scholars spotlighting the three intertwined pathways that produce educational inequality: familial endowments, self-motivated effort levels, and individual position in the social structure. Liu emphasized the significance of diverse effort levels in attaining educational and social success. However, there remains limited attention to inequality of effort and its mechanisms in the Chinese context, which calls for further research.

To explore the mechanisms underlying educational inequalities, it is essential to consider the role of individual efforts in conjunction with circumstantial factors. These two domains are closely interrelated and must be viewed within the broader context of China's social structure. Building on Wang's (2012) framework, this thesis contends that effort can counteract socioeconomic disparities in various ways, especially given the complex urban-rural educational divide in China. While

circumstances are a primary driver of inequality, the level of individual effort, as a manifestation of one's capabilities, can have a counterbalancing effect. Threrfore, it is important to acknowledge the critical role of resources in promoting educational quality and equality and to assess the significance, function, and power of individual effort in goal attainment and social status acquisition.

In conclusion, this thesis underscores the significance of effort as a direct predictor of students' educational outcomes and recognizes the value of effort-based learning ability as crucial student-specific inputs, rooted in theoretical models of the educational reproduction process. The thesis highlights the potential and capability of effort to mitigate outcome inequalities, arguing that individual learning motivations and exertions can complement, compensate, and even counteract family background disadvantages in persuing equitable outcomes. It further posits that effort operates as a redress mechanism: by rewarding students' for their effortful behaviors, such as dedicating more time and energy to learning, the effort can offset the imbalanced educational resources inherited from family backgrounds, potentially sustaining, decreasing, or eliminating existing educational inequalities. As such, enhancing students' various efforts would be a rational approach to positively impact learning outcomes in the Chinese context.

3.   Outline of the Studies

Previous research has demonstrated that family background and school resources, especially social capital within both contexts, significantly impact on academic outcomes (Hægeland et al., 2005). Numerous studies have explored the relationship between family background, school effectiveness, and educational outcomes. However, there is a paucity of research on the importance of various efforts regarding psychological motivation and behavioral devotion in learning, particularly in China. This lack of attention is surprising given the established significance of effort in educational outcomes (Gardner, 2014). While some studies have emphasized that family involvement and parental expectations can shape educational outcomes (Yamamoto & Holloway, 2010; Froiland & Davison, 2014), the interconnections between social origin-related parental educational perceptions and student effort levels remain under-researched, except for a few studies on intergenerational transmission (Schmitt-Wilson, 2013; Wu et al., 2018).

Therefore, the present thesis aims to examine the characteristics of high-performing educational outcomes, specifically the roles of parental, school, and individual effort involvement in shaping students' academic results. Although the literature has extensively documented the separate associations between these three factors and student academic success (Rivkin et al., 2005; Meece et al., 2006), research on which aspect dominates when all three factors are integrated into one context is limited. Additionally, there is a lack of quantifiable methods to accurately compare or extract significant impactors in educational outcomes (Sandelowski, 2000; Queirós et al., 2017).

This thesis is devoted to developing feasible approaches to examining the roles of family, school, and individual effort in achieving high-performing learning outcomes. Adopting an interdisciplinary stance, it blends insights from psychology and educational research to understand disparities in student outcomes stemming from intergenerational effort transmission within families. Embracing a multi-

faceted perspective, this thesis explores the connections and relationships between circumstantial backgrounds, effort levels, and educational outcomes. Furthermore, it amalgamates both circumstantial and effort-related factors to catch sight of their independent and interactive mechanisms in sustaining academic success. By utilizing data from the China Education Panel Survey (CEPS) and conducting three progressive sub-studies, this research promises to shed light on the multifarious influences on educational outcomes, concurrently presenting a data-driven approach to nationwide exploration across CEPS survey cycles. The outlined framework for the three sub-studies is depicted in Figure 1, offering a comprehensive visual representation of the research trajectory.

Study I aims to investigate the comparative significance of family support and school input in driving disparities in students' educational outcomes. Its primary objective is to determine whether family support plays a more pronounced role in widening the achievement gap compared to school resources. To achieve this, this study assesses the relative importance of variables in both groups by calculating the marginal contribution of each variable to the explained variance (R^2), while controlling for personal characteristics. Furthermore, it employs quantile regression to analyze the heterogeneity in the impact of each predictor on students with varying abilities. The China Education Panel Follow-up Survey (CEPS 2014-2015) is utilized as the dataset to address these research inquiries, comprising a sample size of 4,938 students from 112 schools.

Study II explores the association between students' socioeconomic background and their levels of effort, with the objective of uncovering the underlying factors that contribute to intergenerational transmission of effort from parents to children. Additionally, this study investigates the combined effects of student's socioeconomic background, effort level, and academic achievement. This research builds upon existing literature on effort by providing empirical evidence of its impact on academic achievement. While previous studies in education primarily establish correlational relationships, this study goes further by attempting to estimate the causal effect of effort on academic test scores. This estimation is

derived by analyzing within-student effort variation and controlling for shared factors within the student's cohort using class-year fixed effects. The dataset for this sub-study stems from the CEPS 2013-2014 baseline and 2014-2015 follow-up surveys, encompassing a sample of 24,974 students from 112 schools across 28 provinces.

Study III seeks to forecast educational outcomes by evaluating the effectiveness of machine learning models in extracting the most crucial features from a high-dimensional database. Building upon the econometric work of Simon and Tibshirani (2012), this research identifies the most predictive factors that influence how social inequalities shape educational outcomes, considering a pool of 45 potential effort-related variables. This study thoroughly analyzes four machine learning methodologies: Lasso, Random Forest, Adaboost, and SVR. It ranks individual and collective effort factors to elucidate their relative significance in determining students' academic achievement. Additionally, the study performs a gender-based heterogeneity test to identify potential differences between boys and girls in their attainment of higher academic performance. Two waves of the CEPS dataset, focusing on a sample of 24,974 students from the 7th and 8th grades across 112 schools, form the research foundation.

Overall, this thesis addresses the limitations of prior research on the impact of family background and school resources on academic outcomes by conducting three sub-studies. These sub-studies conceptualize socioeconomic status (SES)-based effort factors as tangible effortful behaviors exhibited by parents and schools throughout students' learning progress, alongside students' psychological determinations and motivations. All sub-studies aim to explore the mechanisms causing disparities in how schools, parents, and students perceive or strive for academic excellence, resulting in diverse academic and social outcomes. All sub-studies aim to explore the mechanisms causing disparities in how schools, parents, and students perceive or strive for academic excellence, resulting in diverse academic and social outcomes.
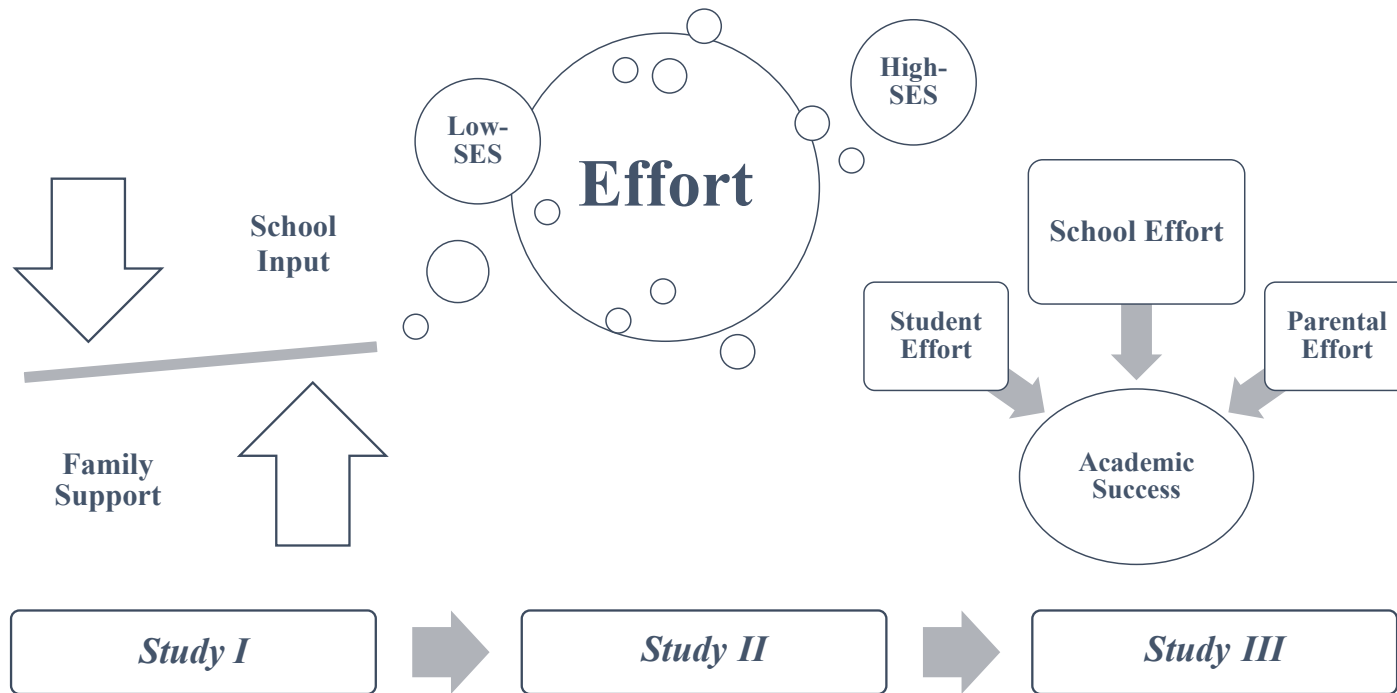
Fig.1 Outline of the three sub-studies

4. General Discussion

4.1. Synthesized Outcomes

The present dissertation aims to investigate the factors influencing family, school, individual effort, and educational outcomes. Its primary objective is to offer a holistic understanding of the sources of outcome disparities. *Study I* examines the relative importance of family support and school input in enhancing academic performance among junior high students. It determines whether students with extensive family support and active parental involvement outperform their peers academically or if high-quality skills and cultural knowledge acquired from schooling can help students compensate for a disadvantaged background. To quantify the relative contributions of family support and school input, the study calculates their respective impacts on R^2 of student achievement. The findings reveal that family support holds a more pronounced effect, boasting a Relative Importance (RI) value of 48.16%, in contrast to school input, which registers an RI value of 28.29%. To further explore the variation in the effects of 15 related predictors across different points in the achievement distribution, a subsequent quantile regression analysis is conducted. This assessment reveals that facots such as parents' highest educational level, family cultural capital, and gender differences markedly affect students who exhibit relatively low academic performance. Moreover, the study finds that while teachers' educational level significantly shapes academic achievement, its importance diminishes as student performance improves. Such insights suggest that students with lower-performing students might derive greater benefit from certain public expenditures and that they tend to lag behind their peers with well-educated educated parents, primarily due to disparity in cultural capital instilled through home-based education.

Study II provides evidence underscoring the significant role of student effort in academic achievement. However, it also highlights that family socioeconomic status (SES) exerts a greater

influence on academic success. This revelation does not diminish the importance of effort, nor does it imply that low-SES students cannot improve their performance through hard work. Instead, it underscores the persistent educational inequalities, highlighting the imperative for targeted interventions to support low-SES students. Interestingly, low-SES students tend to demonstrate higher levels of effort compared to their high-SES counterparts. Moreover, they reap greater benefits from this amplified effort, leading to notable enhancements in academic outcomes. Such observations emphasize that increased effort can help mitigate the educational disadvantages faced by low-SES students, challenging the prevailing belief that family SES poses an insurmountable barrier to academic success. Furthermore, the study reveals that decreased effort has a more pronounced negative impact on the performance of low-SES students. This draws attention to the paramount importance of leveraging student effort as a pivotal intervention mechanism, aiming to cultivate a level playing field for students irrespective of their socioeconomic backgrounds. These research findings hold significant policy implications in the Chinese context, where the influence of effort on academic achievement is particularly emphasized. Policymakers can suggest the implementation of incentives to recognize and reward effort for both students and parents, placing a keen emphasis on tailoring interventions for students from low-SES families. Such policy maneuvers can adeptly tackle the disparities rooted in socioeconomicdevides, promoting a more equitable educational landscape.

Study III employs machine learning techniques to examine the predictive power of individual predictors and their categorical groupings, which are crucial for accurate prediction tasks. The results of the four machine learning examinations highlight the significant role of effort-related factors in students' educational attainment and achievements. While students with similar family backgrounds and schooling preferences might exhibit variations in academic performance, thees variances in educational outcomes cannot be solely attributed to objective structural positions or family backgrounds. Latent motivation and tangible action efforts also contribute to the stratification of academic achievements. The

findings suggest that the varied approaches and actions of parents, schools, and students perceive and towards academic excellence can lead to disparities in educational outcomes. Specifically, parental requirements for their child's academic performance, students' and parents' educational expectations, and parental involvement in school activities emerge as the most influential factors in determining students' grades. Nonetheless, the impact of a student's individual effort on their academic performance is found to be limited. This suggests a dominant role for schools and parents over the students themselves in molding academic achievement. Moreover, a gender-based analysis reveals an interesting pattern: for girls, school effort has a more substantial impact on academic performance compared to parental effort, whereas the opposite holds true for boys. This observation helps explain the emerging pattern of enhanced academic achievement among girls in China. As policymakers increasingly direct attention and provide financial incentives to schools and teachers, such strategies are poised to yield greater improvements in girls' academic performance relative to boys. In sum, this study highlights the importance of exerting more effort to achieve better academic results, rather than merely relying on increased material resources from families or acquiring higher-quality teaching faculty and facilities from schools.

This research on educational outcome inequality can be likened to a projector, illuminating the past, introducing the analytical process, and shedding light on the complex causes and interrelationships of outcome inequality from diverse perspectives of sociology, pedagogy, and psychology. This thesis has untangled the intricate components and mechanisms underpinning this phenomenon. However, the complexity of this issue is far-reaching, with various contingent and unavoidable factors intertwined. In the following subsection, I will discuss the theoretical and practical implications of this thesis. I will also assess its strengths and limitations, acknowledging that, while this study offers valuable contributions, there remain facets that require further exploration and refinement.

4.2. Theoretical Implications

As educational inequality patterns have evolved, research on this topic has shifted its focus as well. This thesis provides a pathway for the next stage of research, transitioning from measuring educational inputs to exploring students' academic achievements, from comparing educational opportunities to examining the components of educational outcomes, and from enabling research approaches to its progress incrementally. Meanwhile, the factors that influence educational outcomes have become more complicated and nuanced. This thesis introduces multiple elements impacting student achievement, including family socioeconomic status, cultural and social capital, educational expectations, motivation, and effort. Presently, educational inequality is perceived as a multifaceted process entailing a myriad of influences (Blossfeld, 2019). Addressing these multi-dimensional factors can yield more objective and precise research results. We can, once more, trace educational inequalities back to deeper socioeconomic roots.

This thesis enhances the current understanding of the potential factors that lead to educational inequalities by consolidating viewpoints from educational sociology with econometric methodologies, notably machine learning techniques. The research sheds light on how family background, school resources, and effort levels might sculpt and intensify educational disparities. *Study I* examines the effects of social inequalities on student achievement caused by family and school disparities, whereas *Study II* expands on the understanding that various efforts, motivated by and transcending social origins, may differ for students from distinct socioeconomic backgrounds. *Study III*'s findings are especially salient, highlighting the far-reaching influence of parental and school effort on students' academic success.

Prioritizing solely investments rooted in socioeconomic status (SES) in education, such as family background and school resources, might inadvertently exacerbate the achievement gap if not

accompanied by careful evaluation of effort levels among students from diverse socioeconomic backgrounds. Research shows that fully motivated efforts, especially subjective efforts, can lead to better academic outcomes for students regardless of their SES (Huang, 2015). Therefore, future research on social and educational outcome inequality should consider the potential for effort, recognizing that its effects may vary across socioeconomically diverse groups.

The empirical findings of this thesis suggest that student educational outcomes are markedly shaped by both their socioeconomic backgrounds and their learning efforts. *Studies I* and *II* confirm that family background is a significant predictor of academic success while the role of effort should not be neglected. They also spotlight the essential nature of parental involvement—particularly expectations and confidence—in bolstering student success. Furthermore, *Study III* provides a more nuanced understanding of the interplay between effort levels and students' academic achievements by examining the efforts exerted by three key agents: parents, schools, and students. The thesis concludes that school and parental effort are instrumental determinants of academic achievement. Such factors should be perceived as collaboratively molded by parents, schools, and students (Schönpflug & Yan, 2013; Wu et al., 2018), rather than exclusively attributed to a student's personal traits or actions throughout their learning process. These insights enrich the wider discourse on educational inequality, emphasizing the necessity to consider the complex and multifaceted nature of factors influencing student achievement.

In summary, this thesis considers effort to be a key outcome variable that is firstly shaped by students' characteristics and competencies. Drawing on the findings of three specific studies, it also demonstrates the crucial role of parental and school effort, both individually and in combination, in promoting positive educational outcomes. The thesis argues that family backgrounds and socioeconomic status are important drivers of individual effort, which in turn separately and significantly impacts educational equity. These revelations make important contributions to the literature on the sources of

inequality in educational outcomes, and represent a significant advance in our understanding of the factors and pathways that shape educational outcome inequality.

4.3. Practical Implications

The role of parental involvement and school actions in promoting positive educational outcomes has gained unprecedented attention in recent years. While involving families in education may enhance student achievement, it is not sufficient to fully address the underlying inequalities in educational outcomes. Despite the recent advent of raising academic requirements and standards, improving teacher quality and effectiveness, and identifying and assisting disadvantaged families, these improvements are unlikely to succeed if students are not putting in sufficient effort to learn. Moreover, being effortful is not a static trait; rather, it can be positively or negatively influenced by various factors, including school resources, family background, and individual characteristics. For a more equitable outcome, it is necessary to implement high-quality initiatives that boost both learning efficiency and the degree of effort. Understanding the complex factors influencing student effort and crafting evidence-based strategies to promote increased effort and equity in education is crucial. While prior research on the efficacy of initiatives to improve educational outcomes and student efforts is somewhat limited, this thesis proposes concrete actions that families, schools, and students can take to promote educational outcomes and devoted effort levels:

1) A one-size-fits-all solution is insufficient to motivate every student. Differentiated effort levels exist among different student groups and even within the same student based on family (both parents and students) expectations and SES contexts. Enhancing students' effort levels frequently necessitates a combination of parental involvement and school strategies, and students' self-efficacy, addressing the explicit reason why a student is drifting away from better academic performance.

2) Schools should carefully and thoughtfully implement motivational strategies to increase students' self-determination and susceptibility to incentives. Appropriate and effective school schemes to optimize achievement and efforts are commonly accomplished in tandem with adjustments in curricular contents, instructional practices, teacher and student interactions, classroom management, and school atmosphere. Such strategies should span all educational phases and tackle disparities in outcomes and effort resulting from socioeconomic differences, incorporating high-quality tutoring and tailored instruction.

3) Family programs that are culturally attuned and reward students' based on skill development, progress, and growth tend to be more effective than those merely focusing on achieving specific performance benchmarks. Assume parents inspire perseverance, sheer determination, investigation, and imagination, and incentivize actions that fall under the student's self-regulation. In that case, it appears to be more stimulating than honoring the genetic talent and intellectual capacity or imposing targets on students who have refused to accept them.

4.4. Research Limitations

This thesis argues for the critical role of circumstantiall and effort-based factors in influencing educational outcomes. However, it is subject to several constraints typical of educational research. A primary constraint is the dearth of experimental or quasi-experimental studies (Gopalan et al., 2020). All three sub-studies rely on the same sample population due to the paucity of available data. The use of self-reported data, which might be prone to bias and reporting errors (Podsakoff et al., 2003), is another limitation. These restrictions should be recognized when interpreting the results and generalizing them to broader populations. Nevertheless, the thesis provides valuable insights into factors shaping student effort and academic outcomes, serving as a foundation for subsequent research addressing these identified limitations.

Firstly, the limitations of large panel research databases need to be acknowledged when interpreting findings. In this thesis, the same CEPS data source, used in three sub-studies, covers a sample of about 30,000 students, including information from questionnaires with a large subsample of parents or students. While the CEPS database provides a wealth of information, its reliance on self-reported data poses challenges. Verifying the congruence of reported and actual behaviors is impossible. For instance, parent involvement data relies largely on reports from parents, students, and educators in structured interviews or questionnaires, which might lack reliability and immediacy (Becker, 2005). Hence, the findings in this thesis should be interpreted with caution, taking into account the limitations of the data source.

Secondly, while these sub-studies cross-check parent feedback with student and teacher responses to improve data validity, the findings underscore the profound effect of parental involvement, from both socioeconomic and effort perspectives, on student' achievement. The more support and involvement children receive from their families, the better their learning outcomes will be. However, given the survey-based nature of these studies, ascertaining the causality between parental involvement and academic success is challenging. While there is a clear positive relationship between higher parental involvement and improved academic achievement, the order of influence remains ambiguous (Duncan & Magnuson, 2012). It's feasible that high-performing students elicit increased familial engagement rather than vice versa.

Thirdly, this thesis, while analyzing circumstantial and effort-based factors influencing educational outcomes, fails to explore all potential explanations for the observed trends. The predictors'data, sourced from the questionnaires' two-wave data, remains aggregated. The intricate interplay between contextual variations and uneven educational outcomes implies that certain elements may resist straightforward classification and might only influence specific outcomes alongside other variables (Becker et al., 2016). This leaves room for a more granular interpretation of findings. Further inquiries, rooted in a

comprehensive context grasp, could probe the nuances of these shifts within the Chinese educational landscape.

Additionally, national panel surveys usually span multiple subjects, seldom delving deeply into any specific area. While CEPS offers abundant data for this thesis, it wasn't explicitly crafted for this research purpose, restricting analyses to the extant survey data.

In summary, while open-access data sources like CEPS bring notable benefits, they come with inherent limitations, such as data incompleteness and insufficient metadata. Secondary data sources in general must balance quantity with appropriateness, which requires careful consideration of data validity and analysis robustness. As such, it is essential to employ flexible and experimental techniques to obtain reliable information, clarify complex procedures, and generate new hypotheses. These processes may involve the development of new research questions and hypotheses, as well as the exploration of alternative data sources and research methods. Careful attention to data quality and transparency can help to increase the rigor and credibility of research findings, ultimately enhancing the impact of research on educational policy and practice.

4.5. Conclusion

This thesis is grounded in the observation that students' educational outcomes arise from a complex interplay of factors, encompassing school resources, family background, and various levels of effort. While psychologists and educators have acknowledged the significance of these factors, Chinese research on educational outcomes has sparingly addressed the role of effort as a standalone contributor to the learning process, both in theory and practice.

In this thesis, I have developed a theoretical framework to articulate the dynamic interrelationships among family, school, and student effort. Specifically, I delineate how students respond to parental

involvement and school resources, how schools adapt to student effort and family background, and how parents react to their child's performance and school preferences. Although these factors aim to achieve the best educational outcomes for students, their multifaceted interactions can sometimes produce unintended consequences. For instance, excessive family diciplines might curtail a student's intrinsic motivation to learn.

To substantiate the theoretical framework, this thesis utilizes the rich dataset provided by the China Education Panel Survey (CEPS). This survey tracked the same cohort of Chinese junior high school students from enrollment to graduation. The data collected between 2013 and 2015 included extensive standardized test results and composite questionnaires completed by students, parents, teachers, and school principals. Multiple indicators were used to construct measures of the potential impactors involved in the education process, including effort exerted by different agents. Specifically, for students, self-reported data were used to measure the amount of time they spent studying and their motivation to achieve academic goals. The degree of parental involvement in a child's education was assessed by factors like supervising homework and attending teacher meetings. To capture the commitment level of schools, variables such as the implementation of interventions to support academic growth and development, the availability of academic guidance services for students, and the disciplinary methods employed were considered.

The empirical results validate the theoretical framework introduced in this thesis. This framework posits that educational outcomes are shaped by an interplay of three primary factors: family background, school resources, and individual effort. The measures of effort identified in this thesis appeared to be appropriate and reveal a trade-off among family background, effort level, and educational outcomes. The findings suggested that student achievement is directly influenced by students' objective and subjective effort, which are, in turn, shaped by socioeconomic conditions. Strategies aiming to stimulate parental effort levels can be effective in boosting educational outcomes in this context, given that

parental involvement and parenting style are more easily influenced than family background. The results also indicated that school effort has a more flexible effect on academic success than school resources, and parental effort is more important than students' individual effort. Furthermore, the thesis found that girls consistently outperformed boys both academic performance and exerted effort, regardless of family background or school resources. This observation might elucidate the recent shift towards improved academic results among junior high school girls in China. Overall, incentives that promote effort from schools and parents to improve student performance could be more promising than attempting to alter family background or reallocate school resource.

The primary objective of this thesis was to examine the key factors that determine student educational outcomes and to identify potential mechanisms to enhance student performance. The thesis underscores the joint efforts of students, their parents, and schools as paramount in optimizing academic results. The theoretical framework presented highlighted the strategic interaction between the participants in the educational process. The research emphasizes the synergistic role of student effort and family background as harbingers of educational success, with the impact of effort magnifying alongside socio-economic status (SES). Specifically, the thesis reveals that objective effort, measured by time spent on learning, is more significant for high-SES students. In contrast, subjective effort, represented by self-perceived effort, merges as more crucial for low-SES students in securing commendable outcomes. Furthermore, the research highlights that lower-SES students tend to work harder but achieve comparatively lower test scores, whereas students from disadvantaged backgrounds are more likely to earn better academic grades with less working time but higher subjective efforts.

The next stage of the research is to investigate the underlying factors that prompt students, their parents, and schools to devote more effort. By understanding the reasons behind the effort put in by the key stakeholders, policymakers can devise effective policies to enhance student performance. For instance, fostering parental and student effort among low-SES families may be a more productive

approach than expecting a change in their socioeconomic circumstances. It is crucial to note that the context in which schools function has evolved fundamentally, with changes in motivational mechanisms inside schools and the competitive atmosphere. Thus, identifying the underlying factors that influence practices at the core of the education process is vital to assess the impact of the ever-changing circumstances and anticipate the potential impact of future policy reforms.

This thesis's conclusions offer promising avenues for refining public policy and resource distribution protocols in China. However, a couple of critical domains warrant deeper exploration. First, it is essential to determine whether intergenerational transmissions of parental efforts can explain student efforts and if so, in what manner? Next, research is needed to identify efforts that could mitigate the impact of socioeconomic background on student outcomes. To fully comprehend the function of individual efforts as a mechanism of reproduction or compensation for disadvantages, it is imperative to consider students' perceptions of their parents' expectations, behavior, and interactions. Future research should focus on the efforts of parents and schools to isolate confounding factors and better examine educational outcomes as both conditions and targets for social equality. It is paramount to contemplate the relationship between students' effort levels and their social origins as a dynamic and complete unit in influencing educational outcomes. Adopting such an approach can foster the development of better educational strategies to bridge educational outcome inequalities.

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Appendix

Study I

The Relative Importance of Family Support and School Input on Student's

Academic Achievement

Abstract

This study investigated the relative significance of family support and school input variables on the academic achievements of 8th-grade students. Data from 4,938 students attending 112 junior high schools in China was analyzed using the CEPS 2014-2015 database. The study quantified the importance of various family and school-related variables by examining their contributions to the R^2 value of the regression. Empirical findings revealed that the highest educational level attained by parents was the most influential factor, accounting for 20.19% of the contributions to the R^2 value. In contrast, the highest educational level of teachers contributed 12.37%, surpassing other variables. When analyzed holistically, the cumulative impact of family support on students' academic achievements stood at 48.16%, whereas school input accounted for 28.29%. Across all models, family support variables consistently exhibited a stronger predictive power for students' academic outcomes than school input variables. This study underscores the importance of parental involvement in children's education, irrespective of their income or educational background.

Keywords: Family Support; School Input; Academic Achievement; Relative Importance Analysis

1. Introduction

Academic research has shown that Student's Academic Achievement (SAA) is intricate, shaped by numerous interconnected variables. Family support and school input are two important factors that can influence SAA. While previous literature has highlighted the role of family background on student learning and development and have suggested that family support variables can have a more pronounced impact on children's academic achievement than school-based influences (Harris & Sass, 2009, 2011). In contrast, some research challenges the effectiveness of schooling, demonstrating that school inputs can have a powerful impact on scholarly output after controlling for family background factors (Knoeppel et al., 2007; Du & Hu, 2008). Nevertheless, there is no consensus on whether family support or school input variables have a greater influence on SAA. Given the multifaceted nature of SAA, it is crucial to assess both family and school factors when attempting to understand the factors that drive academic success. Further studies are vital to determine the relative significance of these factors in bolstering students' academic outcomes.

This study aims to address a gap in the literature by examining the relative contributions of family support, school input, and personal strengths to children's academic performance. Specifically, it investigates the individual and collective importance of family and school-related variables in explaining student academic achievement. To accomplish this goal, the study employs the 2014-2015 China Education Panel Survey (CEPS) dataset. This dataset provides an extensive overview of students' families, schools, communities, and macro-social structures that could influence their academic outcomes, facilitating the identification of distinct and combined impacts of various educational factors on students' performance.

Empirical research in education frequently grapples with the challenge of determining the relative importance of conceptually and empirically correlated predictors. A prime concern is collinearity, which

emerges when two or more predictors are highly interrelated. In conventional linear models, assessing the effect size of each variable through overall R^2 or regression coefficients can be challenging. This complexity arises because a shift in one predictor invariably induces a change in the other, making it hard to distinguish their unique individual contribution (Grömping, 2007, 2009). Typical strategies to address collinearity include selecting uncorrelated predictors, eliminating predictors with the highest correlation, devising separate models, or incorporating all variables. However, these techniques have inherent limitations, such as decreasing the model's explanatory power or producing results that do not represent the overlapping prediction accuracy and interaction among predictors (Fortin et al., 2011). In contrast, this study adopts a Relative Importance (RI) analysis, drawing inspiration from the methodologies of Krasikova et al. (2011) and Tonidandel and LeBreton (2011). This dominance analysis, firmly established in the realm of social science, gauges the unique and mutual contributions of one predictor in the context of others. It does so by discerning the extent of various explanatory variables' influence on the coefficient of determination, R^2. By leveraging this technique, this study can provide a more comprehensive understanding of the relative contributions of diverse educational factors on children's academic performance.

This study specifically employs the Relative Importance (RI) analysis to identify the contributions of various variables to the coefficient of determination (R^2) of the model. This is done both individually and in combination with other explanatory variables, all aimed at elucidating student academic achievement (SAA). To tackle the issue of collinearity, which complicates the task of pinpointing the unique contributions of each variable, all variables were incorporated into the model. Relative rankings, complemented by percentage estimates, were used to explain the role of each predictor' in shaping SAA. The results identified the parents' highest educational level as the foremost individual variable, followed by family cultural capital and gender disparities. Notably, the total impact of family support on SAA was was approximately double that of school input, indicating that family support plays a relatively more

crucial role in determining SAA than school inputs. These findings hold substantial implications for improving student academic achievement and provide insights for shaping future compensatory measures and policy interventions.

The empirical findings presented in this paper resonate with existing literature on reproduction and social capital theories. These theories postulate that family background plays a dominant role in shaping student outcomes and exerts a more significant influence than school effects. Specifically, the findings indicate that family support variables, such as cultural capital, play a more critical role in student academic achievement compared to any single school input and controlled variables. Across all examined models, both parent's and teacher's educational levels consistently and positively affected SAA, corroborating previous research by Mancebón et al. (2012) and Xue & Wang (2010). Thus, this study highlights the importance ofwell-educated parents, strong cultural capital, and effective parental involvement as key drivers of student academic achievement. These elements are even more crucial than presence of highly qualified teachers in schools. The insights gleaned from this study have important implications for policymakers and educators striving to improve student academic achievement.

The next section offers a review of the relevant literature. Section 3 describes the data source and measurement procedures used in the study. Section 4 details the research methodology while section 5 presents the empirical findings. Section 6 concludes the paper.

2. Theoretical Background

This section reviews literature pertaining to factors that have the potential to impact academic achievement in students. Drawing on the theoretical framework established by reproduction theorists, this study posits that education acts as a mechanism for perpetuating social class. Herein, advantaged groups, or those with favorable family backgrounds, achieve higher educational outcomes, leading to an

elevated social class status. This cycle sustains their position at the top of the social hierarchy (Bowles & Gintis, 1976; Bourdieu & Nice, 1977). The machinery of social capital reproduction is instrumental in this dynamic. Children hailing from more affluent socioeconomic backgrounds not only have enhanced access to education (Nash, 1990) but also tend to excel academically, buoyed by familial economic support and a conducive cultural environment (Graaf et al., 2000; Sullivan, 2001).

Coleman (1988) argued that family background family background shouldn't be viewed as a monolithic factor distinct from schooling. Instead, it can be broken down into three core components: material capital, human capital, and social capital. However, the positive effect of parental human capital on children's learning and development is dependent on the presence of social capital within the family framework. Without parents being actively involved in their children's education and daily lives, the human capital they possess may not effectively contribute to their children's growth (Chunling, 2015). Further, family economic capital has been shown to positively influence both on the rate and duration of participation in shadow education (Bray et al., 2014; Li & Qiu, 2018). Therfore, when evaluating family support elements, it is critical to reaffirm the influence of social capital on educational outcomes. This is particularly evident in the impact of parental involvement, such as educational companionship and homework instruction, on students' academic achievement. A number of studies have shown that parental involvement is positively associated with academic success (Dahl & Lochner, 2012).

Hanushek (1989) developed the education production function model, which posits that school resource inputs—such as financial allocations, resources, teacher qualifications, and class size—affect education outputs, including student academic achievement. Building upon this model, subsequent research has identified a range of factors that influence student academic achievement. Notably, factors such as after-class learning duration (Yang & Zhao, 2021), peer effects (Guo & Chen, 2020), students' interpersonal relationships (Zhang, 2016), the quality of communication and relationship assessment between teachers and parents (Ling, 2016), the quality and quantity of teachers (Cebolla-Boado & Soysal,

2018), the economic status of schools (Zhao et al., 2017), and governmental support (Hu, 2018) all play significant roles in student academic achievement. Additionally, school input-related conditions—including per-pupil expenditure, the headmaster's curriculum leadership, teaching strategies, teaching experience, teacher working hours, student study duration, and learning methodologies—are also impactful on student academic performance (Caro, 2016).

A significant body of literature has established that both family support and school input variables are key determinants of student academic achievement (SAA). However, a consensus is lacking on which of the two has a comparatively greater impact on academic performance. Student's academic outcomes are shaped by a myriad of factors stemming from both family and school environments. To fully grasp the influences on SAA, it is crucial to examine these elements in an integrated framework while controlling for individual variances. Overlooking either of these dimensions can lead to a skewed or ecological fallacy methodology (Curran & Bauer, 2011).

To bridge this gap, this study proposes a set of hypotheses (as shown in Table 1) to identify the relative importance of individual and group variables on SAA, building upon the existing literature. By testing these hypotheses, I aim aim for a holistic understanding of the determinants of students' academic prowess. It is expected that this refined insight will enable us to predict SAA more accurately, and thereby, improve stduents' educational outcomes.

Table 1 Hypothesized Effects of Family Support and School Input on SAA

Research questions and Hypothesis	Hypothesized effects
A. Can disparities in students' academic achievement be attributed to:	
1a. Family educational capital	+

H1: Differences in family educational capitals?	1b. Family cultural capital	+
	1c. Parental political capital	+
	1d. Family economic capital	+
H2: The compensatory role of parental involvement?	2a. Participation in shadow education	--
	2b. Family instruction after school	--
H3: Variations in teacher quality?	3a. Teachers' educational levels	+
	3b. Teachers' professional titles	+
	3c. Teachers' years of teaching experience	+
H4: Differences in teacher quantity?	4a. Student-to-'teacher ratio	--
H5: Variability in governmental support?	5a. Fiscal appropriation per student	+

B. Is the cumulative impact of family support variables more significant than that of school input variables in influencing students' academic achievements?

Note: "+" indicates a positive effect, while "--"indicates a negative effect.

3. Materials

3.1 Data Source

To investigate the factors that influence academic achievement, this study uses data from the China Education Panel Survey (CEPS). This survey was conducted by Renmin University of China during the 2014-2015 follow-up period and achieved a commendable follow-up rate of 91.9%. The CEPS stands

as a nationally representative survey, established with the intention of examining the effects of various factors, spanning family, school, community, and broader societal structures, on individual educational outcomes. This study collected data from a large and diverse sample of 4,938 students, 112 schools, and 438 classes. Moreover, the survey provides detailed information about students' family background and school contexts, which are critical in examining the factors that influence academic achievement.

Table 2 delineates the descriptive statistics for all considered variables. The sample is comprised of 51.53% female and 48.47% male students from 122 junior high schools, with 92.59% of the schools being public-funded and 7.47% being private schools.

3.2 Variables and Measures

Dependent Variable. The dependent variable in this study is Student's Academic Achievement (SAA). I use the sum of students' scores in Chinese, Math, and English tests as a measure of SAA, which have been widely used in prior research as a valid indicator of academic achievement (e.g., Bowles et al., 2000). Scores from the mid-term exams of the 2014-2015 academic year served as the source of this data. These scores were provided by the students' respective schools and were verified for accuracy (Wang, 2016).

Predictors. Students' academic achievements depend on students, family, and school factors. I employ three predetermined groups of variables as predictors, which have been widely recognized as crucial factors in influencing educational outcomes. These three groups of predictors are: (1) school inputs, which cover faculty quality and facility quantity; (2) family background, which encompasses social, economic, and cultural capital, in addition to family involvement; and (3) personal characteristics, which include aspects like gender, household registration type, and family structure. These 15 potential

predictors were selected based on their significant impact on SAA, as evidenced in previous research across various contexts.

Controls. The "innate endowment effect", which is managed as a controlled cluster variable in the analysis, encompasses both intrinsic endowment traits and personal characteristics rooted in family origin. In this context, the term "innate endowment" specifically refers to the combined influence of gender (where male is coded as 1) and explicitly excludes other genetic effects, such as noncognitive and cognitive abilities or talent.

Personal characteristics based on family origin consist of two components. The first component relates to household registration prior to enrollment, where urban residence is coded as 1. This variable serves as a controlled factor within the overarching latent family background variable. The second component is a dummy variable, indicating whether an individual is an only child (with non-only child coded as 1). In educational inequality research, the number of siblings is commonly examined as a family background variable due to its relevance in the distribution and utilization of family resources. Therefore, accounting for this variable in the analysis becomes indispensable.

Table 2 Descriptive Statistics

Variables	*Mean*	*SD*	*Min*	*Max*
Students' Academic Achievement *(total exam scores)*	227.4	71.18	6	429
Family Support				
Parent's highest educational level	4.59	2.07	1	9
Family book storage	3.06	1.19	1	5
Parent's political affiliation	2.91	0.41	1	3

Family financial conditions	2.79	0.62	1	5
Family educational companion	0.41	0.49	0	1
Shadow education	3.25	2.04	2	12
Home study instruction	2.22	1.19	1	5
School Input				
Teachers' educational level	8.78	4.37	1	21
Teachers' professional title	5.86	3.73	4	19
Teachers' teaching years	8.02	4.28	1	21
Students to teacher's ratio	1.30	0.42	0.3	2.34
Governmental support	1,081	777.8	0	4,358
Personal Characteristics				
Gender (male=1)	0.51	0.50	0	1
Household registration type (urban=1)	0.46	0.49	0	1
Family structure (non-only child=1)	0.56	0.52	0	1
Schools	63.41	34.44	1	112
Provinces	16	9	1	28
Students	4938	2460	1	4938

4. Methods

To investigate the impact of each variable on students' academic achievements, I first apply a traditional OLS regression. To better isolate the contribution of each explanatory variable to the overall model's R^2, I adopt the Relative Importance (RI) analysis. This method which involves ranks the predictors based on their relative importance by comparing their additional contributions to the variance explained by all possible subset models. When a predictor is added to a given subset model, its additional contribution is measured as an increase in explained variance or R^2.

According to Krasikova et al. (2011) and Tonidandel and LeBreton (2011), I calculate the contribution of each explanatory variable to the coefficient of determination R^2. This should be equivalent to its marginal effect, M on R^2. Specifically, the marginal utility of the explanatory variable x_k on R^2 can be expressed as[1]:

$$M_K = R^2 \left[y = a + b_k x_k + \sum_{j \in S} b_j x_j + e \right] - R^2 \left[y = a^* + \sum_{j \in S} b_j^* x_j + e^* \right] \qquad [1]$$

In this case, S represents the other explanatory variable excluding variable k. As observed, the equation calculates the R^2 of the entire regression minus the R^2 of the regression without variable k. Since the regression coefficients typically change when an explanatory variable is omitted, the coefficients of regressions that exclude variable k are denoted by *.

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[1] The RI analysis in this paper is conducted by Stata command "domin".

When variable k is sequentially removed from the regression, the marginal utility to the R^2 of the goodness of fit will vary. To address this variation, the final determination of the importance of variable k is taken as the average of the results obtained from the different exclusions of $J!$.

To provide a standardized measure for comparing the contribution of each explanatory variable, all RI values are standardized. The ratio of each variable's RI to the overall RI is then calculated to obtain the normalized degree of contribution. The sum of these standardized degrees of contribution for all explanatory variables is approximately equal to one. This standardization facilitates the straightforward comparisons of the relative importance of each independent variable. The results of the Relative Importance (RI) Analysis are presented below.

5. Results and Discussions

5.1 Benchmark Methods

Figure 1 displays the strength of coefficients for each variable, after standardizing all variables. This is depicted through point estimates and confidence intervals (CIs). The results indicate that parents' highest educational level, family cultural capital, and teacher's educational level all exert a positive and significant influence on SAA. Of these, the teacher's educational level has the strongest favorable effect. Conversely, factors such as home study instruction, the number of years a teacher' has been teaching, gender (male=1), house registration type (urban=1), and family structure (only child=1) have a negative and significant effect on academic performance. Notably, the number of years a teacher' has taught and gender differences have the most marked adverse effects. The variables—parents' political resources, family learning companionship, and government support—do not significantly influence SAA. The impact of family financial condition, participation in shadow education, the teacher's professional title, and the student-to-teacher ratio on SAA is marginal, as evidenced by their negligible coefficients.
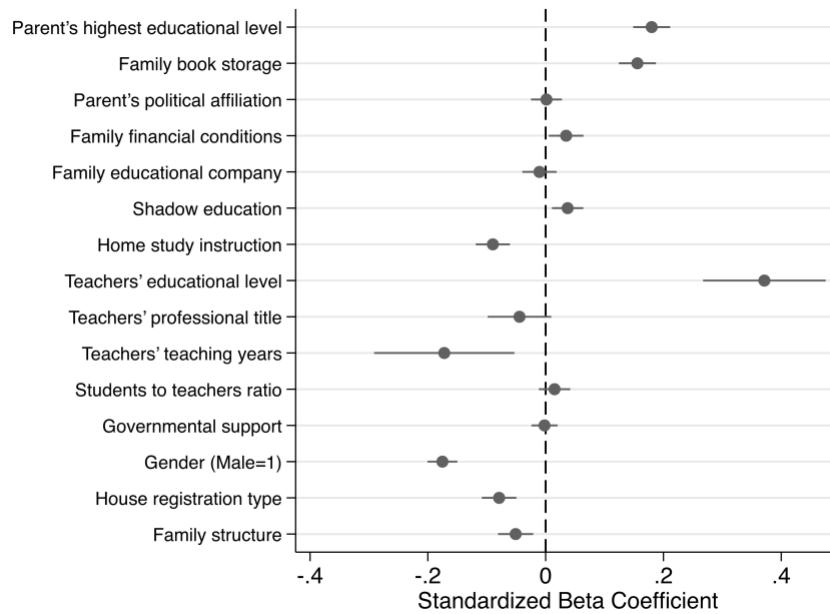
Fig. 1 Standardized Beta Coefficient Plot of OLS Estimated Effects on Student's Academic Achievements

Although the OLS regression analysis provides a partial picture of the factors that influence students' academic performance, it does not allow for a direct comparison between the family support and school input categories. Two reasons may explain why the regression coefficients for some variables are imprecise. Firstly, the selected variables might genuinely play a significant role in explaining the variation in SAA. Secondly, conventional regression methods, which focus on estimating the overall model R^2 and elucidating individual regression coefficients, are context-dependent and subjected to the collinearity issue (Courville & Thompson, 2001). Even small changes in the observations can lead to significant changes in the model since the predictors often vary in tandem. This co-variation makes it difficult to isolate their independent effects. Hence, a sophisticated method is essential to perform a variable importance analysis and achieve a holistic grasp of the relative contributions of how family support and school input categories contribute to students' academic achievement.

5.2 Relative Importance Analysis

Family Support

Table 3 presents the results of the relative importance (RI) analysis, ranking each variable's significance according to their RI values. Specifically, columns (1)-(7) illustrate the RI outcomes for family support variables, segmented by socioeconomic status and extramural education. The results reveal that variables related to family support, especially parents' highest educational level and family cultural capital, possess the most substantial RI values. They account for 54.27% and 53.13% of the total R^2 explained, respectively. Remarkably, the combined contribution of these two variables is almost equivalent to that of the three controlled factors. Additionally, the family's financial condition and shadow education each have an RI value close to one-fifth, demonstrating their significant impact on SAA. Among the seven family support variables, two contribute more than 50% to their respective equations' R^2, while two contribute approximately 20%. These findings support the conclusion that family support has a strong predictive power for SAA.

The results demonstrate that factors such as parental education level, family cultural capital, and family finances significantly predict students' standardized test scores. These findings are consistent with previous studies conducted by Dincer and Uysal (2010), Mancebón et al. (2012), and Witte and Kortelainen (2013). They also concur with *hypotheses H1a, H1b, and H1d,* which suggest a strong association between parental education level, occupational status, family financial conditions, and SAA. In essence, higher parental education levels, a richer family cultural capital, and a more substantial family income correlate with elevated SAA.

Column (3) includes information about the parent's political affiliation (whether they are a member of the Communist Party or not), with a RI value of 3.37%, indicating that it has no significant effect on

SAA. This finding contradicts *hypothesis H1c*, which proposes that a family's political capital would play a vital role in students' academic performance, given that it reflects the social and cultural capital that parents can provide. Typically, political capital is often associated with better educational opportunities for children at the tertiary level and better job prospects in the labor market (Dincer & Uysal, 2010). Nonetheless, given that the present study focuses on junior high school students, there may be limited opportunities for parents to convert their political resources into their children's social capital.

In column (5), the inclusion of family educational companion (Yes=1) yields an RI value of 5.332%, indicating a minor yet positive impact of parental involvement in children's learning on academic outcomes. This finding is in line with *hypotheses H2a and H2b*, which posit that proactive parental roles in aspects like encouraging parent-child interactions, fostering deeper bonds, and setting clear educational expectations can significantly bolster a child's academic journey (Kaplan et al., 2001).

Columns (6) and (7) measure the effects of participation duration in shadow education and home study instruction, respectively. The results show that shadow education exhibits a more pronounced impact than home study instruction. Its RI value of 18.4% underscores its utility as a supplementary educational tool. In contrast, the RI value for home study instruction is relatively low, at 0.49%, implying that academic guidance provided by sampled parents might not reach the expected outcomes.

Overall, these findings reveal that parental education and family cultural capital remain significant factors in predicting students' performance on standardized tests. A robust family support structure, especially in these domains, directly correlates with heightened academic achievement. These findings are consistent with previous research which emphasize the merits of enhancing parents' education and cultural capital for the academic improvement of their offspring (e.g., Buchmann et al., 2010). However, while shadow education is often viewed as an important supplement to formal schooling and a way for

families to provide additional support for their children's education, the study highlights its diminished influence on SAA compared to other determinants. The performance gap among students who participated in shadow education and those who did not was less significant, indicating that while shadow education offers advantages, its impact might pale in comparison to other familial support mechanisms.

School Input

Columns (8)-(12) detail the remaining school input variables: school faculty and facilities, alongside their respective RI values. The results show that the quality of school faculty exerts a greater influence on students' academic achievement than the school facilities. Specifically, the educational levels of teachers (RI value of 47.8%), their professional titles (RI value of 39.05%), and tenure in teaching (RI value of 44.31%) have a considerable impact on SAA. In contrast, both the teacher-student ratio and public expenditure exhibit relatively low RI values under 3%, underscoring the predominant influence of teacher quality on SAA.

Columns (8), (9), and (10) examine the impact of teacher quality on student achievement at the school level, measured by teacher educational level (RI=47.8%), professional title (RI=39.05%), and teaching experience (RI=44.31%), respectively. The results consistently show that these faculty quality indicators wield a profound effect on student achievement, reflected in their leading RI values. Specifically, schools that emphasize superior teacher quality often see their students securing higher standardized test scores. These findings are consistent with *hypotheses H3a, H3b, H3c,* and the mirror the previous research that highlights human capital characteristics such as teacher qualifications, titles, and length of teaching as proxies for teacher quality, which is invariably linked to student academic success (Knoeppel et al., 2007; Xue & Wang, 2010). Furthermore, students taught by high-qualified teachers are more likely to make academic progressions compared to their counterparts taught by lesser-

qualified teachers. These results stress the importance of investing in teacher quality to improve student learning outcomes.

Columns (11) and (12) display the contributions of teacher quantity and financial investment to SAA. With RI values below 3%, there demonstrate weak significant correlations between the number of teachers, public expenditure from central or local governments, and academic performance. This observation aligns with the *hypothesis H4a* and the Coleman Report (Coleman et al., 1966) which posits that school resource investments account for only a minor proportion of the variance in student academic performance, while family support variables outperform in all circumstances.

Personal Characteristics

The consistency of the relative importance of control variables remains steady across all equations (1-13). Gender emerges as a potent predictor of SAA, with an RI consistently hovering around 50%. Similarly, family structure, as measured by whether the student is an only child or not, impacts SAA. Across all equations including family support and school input variables, the RI for family structure spans between 13.76% and 39.74%. These findings highlight the relative importance of family structure and gender in predicting SAA, even after considering other determinants. Notably, the minimum RI value for family structure exceeds the combined RI values of less influential factors like house registration type, parent's political affiliation, home instruction, and school facilities—all of which exert a marginal effect on SAA.

In line with the OLS estimates, gender exerts a considerable impact on SAA, with girls, on average, outshining their male counterparts. This "academic edge" among girls has received widespread attention from educational researchers (Wigfield et al., 2002), given that girls generally excel over boys across diverse subjects and academic stages. While the onset of puberty might partially explain the gender-

based academic performance disparity (Torvik et al., 2021), girls in China benefit from earlier pubertal changes than boys of the same age (Zheng et al., 2015). This early maturation potentially bestows upon girls an edge in garnering superior academic results during their junior high school years.

Family Support vs. School Input

Amongst possible variables in column (13), the most critical determinants of SAA are parents' highest educational level and family cultural capital, boasting RI values of 20.19% and 18.55%, respectively. Meanwhile, students' gender and teachers' educational levels occupy a secondary advantaged position with RI values of 17.77% and 12.37%. The RI value of teachers working length exceeds 8.75 %, close to the sum (9.8%) of the other five inconsequential variables of family support. More specifically, both parents' and teachers' educational levels show a robust relationship with students' academic performance compared to other predictors, contributing to one-third of the total explained variation in SAA.

When considering family support and school input as two distinct groups, it becomes evident that family support variables have a much stronger impact on academic achievement than school input variables. All family support variables have an RI value of over 48%, while school input variables only account for roughly 28% of the total importance. This result confirms *hypothesis B*, asserting that family support is more influential in determining Chinese junior high students' academic achievement than school inputs. Such a trend might stem from the crucial role family educational resources play in academic success—a resource that often eludes disadvantaged demographics due to prevailing educational and economic imbalances (Conger et al., 2010).

Table 3 Results of Relative importance (RI) Analysis on Student's Academic Achievements

Domains	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Gender	29.33% [2]	29.33% [2]	52.9% [1]	45.47% [1]	52.7% [1]	47.13% [1]	54% [1]	31.37% [2]	37.31% [2]	33.94% [2]	52.55% [1]	53.64% [1]	17.77% [3]
House registration type	2.65% [4]	2.22% [4]	5.46% [3]	3.9% [4]	5.25% [4]	3.95% [4]	5.79% [3]	2.35% [4]	2.84% [4]	2.52% [4]	0.564% [3]	5.35% [3]	1.69% [11]
Family structure	13.76% [3]	15.32% [3]	38.27% [2]	29.55% [2]	36.73% [2]	30.43% [2]	39.72% [2]	18.12% [3]	20.8% [3]	19.22% [3]	39.74% [2]	38.59% [2]	4.1% [7]
Parent's highest educational level	54.27% [1]												20.19% [1]
Family book storage		53.13% [1]											18.55% [2]
Parent's political affiliation			3.37% [4]										0.43% [15]
Family financial condition				21.08% [3]									3.42% [8]

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Family educational companion					5.332% [3]								0.67% [12]
Shadow education						18.49% [3]							2.91% [9]
Home study instruction							0.49% [4]						1.99% [10]
Teachers' educational level								47.8% [1]					12.37% [4]
Teachers' professional title									39.05% [1]				6.1% [6]
Teachers' teaching years										44.31% [1]			8.75% [5]
Students to teacher's ratio											2.08% [4]		0.53% [14]
Governmental support												2.42% [4]	0.54% [13]
Combinations	15	15	15	15	15	15	15	15	15	15	15	15	4938

Note: The table summarizes each variable's relative importance indicators (RI) and states their relative rankings in each bracket below. The R-squared value of the model is decomposed into shares from individual regressors, and the RI of each variable represents its contribution to explaining the dependent variable's variance. For additional information, see Shorrocks (1999), Fields (2003), Israeli (2007), and Grömping (2007).

5.3 Heterogeneity and Robustness

Group-level heterogeneity in students' educational resources can significantly affect academic achievement. The selection of schools by parents and the potential confounding effect of unobservable school characteristics may further contribute to endogeneity issues (Ammermüeller & Pischke, 2006). To show heterogeneity in impacts, I exanmine how characteristics included in family support, school input, and personal difference impact distinctively at disparate positions (quantiles) on the student academic achievement distribution. This method is well-suited for investigating heterogeneity in the effects of variables on academic achievement across quantiles of the distribution (Tobishima, 2018; Gershenson et al., 2018). All variables in the Quantile Regression (QR) model are defined as in the previous models, with the subscript "q" denoting the quantile of the achievement distribution. This ranges from 0.1 to 0.9, with higher values corresponding to higher achievement quantiles (e.g., 0.9 represents students in the top 10% of the achievement distribution).

Table 4 specifies QR results for SAA at the 0.25, 0.5, 0.75, and 0.9 quartiles. The regression coefficient for parents' educational level decreases as the student's ability quantile increases, moving from 6.671 at the 0.25 quantile to 4.978 at the 0.9 quantile, suggesting that the marginal effect of parents' educational level weakens as the student's ability improves. Similarly, the regression coefficient for family cultural capital declines as students' ability increases, from 10.54 at the 0.25 quantile to 5.71 at the 0.9 quantile, with a steeper decline than that ovserved for the parent's educational level. However, at the 0.9 quantile, the effects of both variables are roughly equivalent, indicating that the marginal effect of family cultural capital fades as students' abilities heighten. For the top 10% of students, the academic achievement gap associated with family cultural capital gradually narrows, mirroring the effect of parents' educational level. Similar trends are observed for gender, house registration type, and family structure.

Consistent with previous OLS and RI findings, teachers' educational level has a significant positive effect on academic achievement, surpassing the impact of other school input variables. However, the effect of teachers' qualifications diminishes as student abilityadvances, with the coefficient dropping from 0.773 at the 0.25 quantile to 0.406 at the 0.9 quantile. This indicates that as students grow more academically proficient, the contribution of a teacher's educational background to their achievement becomes less pronounced. In contrast, government support mildly benefits students who perform below average but has a slight adverse effect on those excelling academically.

The quantile regression analysis reveal that the impact of certain factors on student academic achievement varies across different SAA levels. Notably, parents' education levels and family cultural capital exert more significant influence on students with lower SAA scores than their higher-scoring counterparts. Moreover, teacher experience proves critical for students with lower academic achievements. Conversely, both governmental support and house registration type significantly affect students whose academic performance is below average. These results suggest that policy interventions aimed at improving student academic achievement should be tailored to the specific needs of different groups of students. Such targeted policies should consider the differential impact of family support and school input factors on academic achievement across different SAA strata, ensuring that resources are allocated appropriately to address the specific needs of disadvantaged students.

Table 4 OLS and Quantile Regression (QR) Estimates on Student's Academic Achievements

	OLS Regression	Quantile Regression			
		$q0.25$	$q0.5$	$q0.75$	$q0.9$
Parent's highest educational level	6.197***	6.771***	5.488***	5.272***	4.978***
	(1.073)	(0.840)	(0.681)	(0.676)	(0.870)
Family book storage	9.287***	10.544***	9.693***	9.462***	5.710***
	(1.588)	(1.388)	(1.125)	(1.117)	(1.438)
Parent's political affiliation	0.232	-3.161	-0.228	0.643	0.881
	(3.060)	(3.402)	(2.757)	(2.736)	(3.523)
Family financial condition	3.997	4.307*	2.677	0.032	3.618
	(3.098)	(2.402)	(1.947)	(1.932)	(2.488)
Family educational company	-1.527	-0.833	-2.256	-2.053	-1.899
	(2.734)	(3.243)	(2.628)	(2.608)	(3.359)
Shadow education	1.304	1.386*	1.071*	0.227	0.836

	(0.944)	(0.728)	(0.590)	(0.586)	(0.754)
Home study instruction	-5.367***	-5.433***	-5.092***	-4.612***	-5.098***
	(1.135)	(1.354)	(1.097)	(1.089)	(1.403)
Teachers' educational level	0.605*	0.773***	0.657***	0.467***	0.406***
	(0.345)	(0.131)	(0.106)	(0.106)	(0.136)
Teachers' professional title	-0.085	-0.017	-0.003	-0.024	0.039
	(0.288)	(0.083)	(0.067)	(0.067)	(0.086)
Teacher's teaching years	-0.286	-0.461***	-0.403***	-0.183	-0.111
	(0.450)	(0.154)	(0.125)	(0.124)	(0.159)
Students to teacher's ratio	0.254	-0.129	0.454	0.855***	0.286
	(1.156)	(0.344)	(0.279)	(0.277)	(0.357)
Governmental support	-0.000	0.005***	-0.000	-0.009***	-0.018***
	(0.004)	(0.002)	(0.002)	(0.002)	(0.002)
Gender (male=1)	-24.962***	-27.843***	-19.966***	-16.582***	-15.428***

	(2.954)	(2.751)	(2.230)	(2.213)	(2.850)
House registration type	-7.261***	-6.702***	-9.096***	-8.553***	-4.746**
	(2.343)	(1.986)	(1.610)	(1.597)	(2.057)
Family structure	-7.275**	-7.578**	-6.489**	-4.843*	-5.365
	(3.555)	(3.202)	(2.595)	(2.575)	(3.317)
N	4938	4938	4938	4938	4938

Note: This table presents the results of selected OLS regression and Quartile estimates at 0.25, 0.5, 0.75 and 0.9 quantiles, all variables are constant to previous models. Standard errors are in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

6. Conclusion

This study investigates the relative importance of family support and school input variables in influencing students' academic achievement. Both OLS and RI results demonstrate that variables related to family and school have profound effects on SAA. Specifically, parents' and teachers' educational levels consistently correlate positively with SAA across all models. Additionally, the study identifies that teacher quality, as measured by years of teaching experience, along with family cultural capital and SES level, as key contributors to students' academic achievement. The results suggest that schools with highly-educated and qualified teachers typically register higher SAA. Simultaneously, students benefiting from educated parents and robust family cultural capital also exhibit elevated SAA.

Importantly, this study reveals that the composite effect of family support is the most important predictor of SAA, while the total impact of school input, although significant, is relatively less critical. These findings underscore the indispensable role played by parents and the home environment in students' academic success. Given the overwhelming impact of family support on academic achievement, interventions and policies should prioritize increasing parental involvement in their children's learning to enhance their academic achievements. Such endeavors must be inclusive, targeting parents from diverse economic, educational, and cultural spectrums.

In conclusion, this study highlights the imperative for policy and practice to recognize the pivotal role of family support in promoting students' academic success. Future research should continue to explore how schools and families can work together to create a supportive learning environment for students.

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Study II

The Role of Effort in Understanding Academic Achievements: Empirical

Evidence from China

The complete bibliographic information of this publication is:

Jin, X. (2023). The role of effort in understanding academic achievements: empirical evidence from

China. *European Journal of Psychology of Education*, 1-21. https://doi.org/10.1007/s10212-023-

00694-5

Abstract

From the perspective of comparative education, it has often been stressed that Chinese families hold high expectations on school achievement and believe in the pay-off of effort. However, the literature on the relationship between effort and academic achievement is limited. Individual effort is not widely considered a significant cause of educational dis- parities, which often is mainly attributed to structural and contextual factors, such as family socioeconomic status (SES). Using the China Education Panel Survey (CEPS 2013, 2014), this study examined the role of effort in affecting educational outcomes and investigated the interplay between effort and family socioeconomic status. The results showed that effort has a positive impact on academic performance, though to a lesser degree than family SES. The study also discovered that low-SES students tend to exert more effort than high-SES students and that the effect of effort is greater for low-SES students. These findings under- lined the importance of individual effort for academic success, particularly for low-SES students, and suggested policies that aim at enhancing motivation and engagement.

Keywords: Educational inequalities, Subjective effort, Objective effort, Socioeconomic status, Academic achievement

1. Introduction

There is a consensus that inequalities in educational outcomes are not solely determined by structural and antecedent contextual elements. A considerable number of studies have examined family background, school resource allocation, and broader economic and social policies (Heckman, 2011; Kim et al., 2018), but these do not fully explain the observed achievement gap. Disparities in educational outcomes still persist among individuals with similar family origins and schooling (Egalite et al., 2016), possibly because of individual differences in their effort level (Broer et al., 2019; Alhadabi & Karpinski, 2020). This study aims to provide causal evidence on the role of effort in academic achievement and to consider the interactions between effort and circumstantial factors such as socio-economic status.

The relationship between circumstantial and effort-related factors affecting academic performance is complex and debatable (Roemer, 1998, 2002). On the one hand, the effort gap between individuals from disadvantaged families and those from favored backgrounds can lead to unequal educational outcomes (Weiner, 2010). On the other hand, individuals are believed to have control over their own determination and effort in the learning process (Price et al., 2010), meaning that differences in educational outcomes could be justifiable if disadvantaged individuals can improve their achievement through autonomous effort (Roberts et al., 2007). In that case, differences in the amount and quality of effort could perpetuate social inequality across generations, given its role in predicting academic achievement (Kautz et al., 2014).

It is widely recognized that there is a synergistic relationship between family socio-economic status (SES), student effort, and academic achievement, where each factor may amplify the impact of the others (Wahlstrom et al., 2010). Ignoring any potential inequalities in effort would obscure the impact of social class on educational outcomes. Accordingly, this study aims to address the following research questions: 1. How does effort impact academic achievement, and what is the relative contribution of effort versus

family SES in determining academic achievement? 2. Who exerts more effort, high-SES students or low-SES students? 3. Whether effort has a greater impact on academic achievement for low-SES students compared with high-SES students?

To address these research questions, I took advantage of the China Education Panel Survey (CEPS 2013, 2014). This survey provides detailed, student-level panel data that encompasses both subjective and objective measures of effort, academic performance, and family demographics (Wang, 2016). The panel structure of the dataset allows for leveraging within-student changes in effort over time, enabling the isolation of the causal impact of effort on academic achievement. Additionally, the utilization of the indigenized dataset offers insights into the unique educational challenges within the Chinese context.

Measuring effort in empirical research poses a challenge due to its subjective nature. To better understand the role of effort, I followed James Steele's (2020) theoretical approach and measured effort both in terms of amount and quality. Specifically, I differentiated between objective effort, which refers to the time spent on learning, and subjective effort, which refers to three self-reported indices of perceived effort (e.g., "I would try my best to finish even the homework I dislike").

Using regression analysis, I found that students who exhibit high subjective effort score 4.4% higher than observably similar students who exhibit low subjective effort. After further controlling for student fixed effects by leveraging within-student variation in effort, I discovered that improving the subjective effort from low to high level leads to a 3.6% increase in test scores. Additionally, increasing daily learning time by 1 hour leads to a 2% improvement in academic achievement. I then compared the relative contribution of effort and family SES by sequentially adding effort and family SES proxies into the baseline model. Results showed that adding SES proxies improved the model fit more than adding effort measures. These findings suggest that although not as influential as family SES, effort does play a significant role in impacting academic performance.

Next, I investigated the differences in effort between high-SES and low-SES students. Through cross-student comparison, I found that high-SES students are 7.3% less likely to report exerting high subjective effort and spend 0.9 hours less on studies than low-SES students. Moreover, I analyzed students' changes in effort from 2013 to 2014 by their SES group and found that a higher proportion of low-SES students improved their subjective effort (low-SES 19.9% *vs.* high-SES 13.6%) and learning time (low-SES 62.6% *vs.* high-SES 56.8%) in 2014 relative to 2013. This further proves that low-SES students tend to be more hardworking in China (Liu, 2017).

In the last empirical task, I examined whether effort impacts low-SES students more than high-SES students. First, I added an interaction term between effort and family SES into the benchmark student-fixed effects model. The results suggest that effort has a smaller effect on test scores for high-SES students. To better understand the mechanism, I segmented the students into groups based on their change in effort and assessed the corresponding change in test scores from 2013 to 2014. For instance, I found that for high-SES students who spend more time on learning, the 95% confidence interval for their score increase is [2.1%, 2.6%], whereas, for low-SES students, the score improvement is between [2.9%, 3.8%]. In contrast, for high-SES students who spend less time, the score change is between [-0.6%, 1.0%], which is statistically insignificant, but for low-SES students, the change is between [-4.7%, -4.1%]. In summary, exerting more (less) effort is more effective (counterproductive) for low-SES students.

This study builds on the effort literature by presenting empirical evidence of the impact of effort on academic achievements. Unlike most empirical literature in education that establishes correlational relationships, this study attempts to estimate the causal effect of effort on academic test scores by looking at within-student variation in effort while controlling for common factors shared by the student's cohort, which are captured by class-year fixed effects. The research findings have policy implications for the

Chinese context, where the impact of effort on academic achievement is particularly emphasized (Guo et al., 2019), such as implementing incentives to reward effort for both students and parents.

In contrast to Spruyt's (2015) assertion that an individual's effort level is not contingent upon their inherent capabilities or backgrounds, this study substantiates that disparities in effort do exist between students from different socioeconomic backgrounds and those from lower-SES backgrounds tend to work harder. Most importantly, it provides empirical evidence that challenges the deficit discourse and supports the findings of McKay & Devlin's (2016) qualitative research. It demonstrates that even students who face significant circumstances-related obstacles can still achieve academic success through high levels of effort.

This study is structured as follows. Section 2 clarifies the definition and measurement of effort, reviews literature relevant to its role in academic achievement, and discusses its relationship with family SES. Section 3 details the CEPS data and explains the construction of variables. Section 4 describes the empirical design, including methodological strategy, empirical results, and discussions. The last section presents the concluding remarks, potential policy implications, and research limitations.

2. Literature Review and Research Questions

2.1 Definition and measurement of effort

Studies in social science have shown that effort is a complex concept. In economics, effort is typically defined as the amount of energy someone puts into a task in contrast to their inherent ability to perform it (Lakhani & Wolf, 2003). Measures of effort can be obtained through real-effort tasks, which evaluate people's behavior while they perform specific, observable tasks (Zipf, 2016). In education, effort is tied to the process of exercising human "subjectivity," which is the commitment to utilizing physical and mental energy to achieve a certain goal or result (Bozick & Dempsey, 2010). In psychology, effort is

seen as a subjective experience that refers to a person's engagement in challenging tasks that require executive functions (Levi et al., 2014), which enables individuals to exercise self-control during effortful tasks.

Steele (2020) offered a clear definition of effort during task performance and promoted a unified understanding across various disciplines by differentiating effort into two distinct forms: objective effort and subjective effort. Steele (2020) posited that "objective effort" is tangible and measurable actions that reflect the amount of energy or work invested in a task, such as the number of hours spent studying, the number of assignments completed, or scores on standardized tests of particular knowledge and skills to be learned or trained (e.g., Trautwein, 2007). On the other hand, "subjective effort" is the intangible and internal experiences and attitudes associated with a task or goal, such as self-efficacy, goal orientation, and intrinsic motivation (Hanushek et al., 2020; Moore & Picou, 2018).

This study adopts Steele's (2020) conceptualization of effort. Specifically, I consider the students' time spent on learning as an "objective effort." Meanwhile, I utilize three questions from the CEPS database that reflect students' conscious representation of their learning investment to measure student-perceived subjective effort. This enables the assessment of both the amount of energy or work invested in schooling and the students' internal experience and associated attitudes, providing a more holistic view of the role of effort and facilitating a better understanding of potential academic obstacles and successes.

2.2 Importance of effort and its relationship with circumstance

The importance of effort in all stages of education has long been proven. According to Dweck (2002, 2010, 2016) and Carini et al. (2006), irrespective of the school quality or the students' socioeconomic background, success in education is impossible without putting in sustained effort. In line with others,

Chunling Li (2015) observed that hard work is a central determinant of educational achievement in China, where it is prioritized over natural ability. Zhang et al. (2023) also contended that the public attributes academic success to effort but not necessarily talent or other inevitable factors, in particular not in China.

Nonetheless, the precise relationship between effort and academic achievement remains unclear. Woessmann & Peterson (2007) saw effort as relative to others and distinguishable from concepts such as ability and talent, while Chadi & de Pinto (2019) considered it complementary or substitute. Chunli Xia (2006) noted that compulsory education in China assumes the ability to be equally distributed among social classes, while effort is entirely regarded as a matter of individual free will. Glewwe et al. (2021) summarized that the lack of a clear understanding of the relationship between effort and academic achievement would hinder the potential effectiveness of approaches in enhancing educational production.

Given the contexts and sociocultural values in which Chinese students operate, examining the exact role of effort on academic achievement is essential. Thus, the first research question is as follows:

Q1: Does student effort positively affect academic achievement?

Furthermore, the impact of family background on academic success cannot be discounted in the Chinese context. Research has suggested that family socioeconomic status is one of the strongest predictors of student success (Gobena, 2018; Jia & Ericson, 2017). However, self-effort and hard work may be just as important in helping students reach their academic goals, despite coming from disadvantaged backgrounds (Wei et al., 2019). The emphasis on "hardship and hard work" in Chinese culture likely contributes to the perception that effort is a more important driver of success than family background (Li, 2010). Given that the specific contributions of family background and "hardship and hard work" to academic success are still inconclusive, a crucial question arises:

Q2: How does the contribution of exerting effort to academic success compare with that of family background in the Chinese context?

Notably, the debate between circumstantial and effort-related factors in determining academic performance is complex. Zimmermann (2013) argued that those with more privileged backgrounds have more resources at their disposal, leading to higher levels of effort, which in turn translates to improved academic performance. Similarly, Schunk et al. (2008) believed that low family SES is often linked to lower levels of effort due to resource constraints and the misalignment of enculturation with societal expectations. This creates an uneven playing field, with those from disadvantaged backgrounds facing an effort gap that is often difficult to bridge, as Marks (2016) noted.

Fletcher & Wolfe (2016) found a similar link between family SES, academic achievement, and effort levels in the Chinese context. While meritocracy assumes that circumstances, such as parental social class, do not influence "merit" (i.e., ability and effort), Liu (2018) believed family SES and school environment influence that effort through ability grouping or tracking. This aligns with the findings of Wang & Li (2018) and Zhang et al. (2020), who concurred that disadvantaged children are likely to experience less parental attention, resources, and activities that would otherwise provide them with the opportunity to devote extra effort to their studies.

Given the evidence, it is meaningful to examine the effort disparities between groups to better understand the relationship between circumstances and effort. Accordingly, the following research question is proposed:

Q3: Do students from disadvantaged backgrounds exhibit greater effort than their more privileged peers?

Most importantly, existing research results for China have never necessitated that relatively disadvantaged children are doomed to underachievement and low effort levels (Li et al., 2021; Zhao & Chen, 2022). As Price et al. (2010) and Gielnik et al. (2015) maintained that students are capable of controlling, or at least partially controlling, their own level of effort, which could lead to improved and more equal educational outcomes, regardless of family background. McKay & Devlin (2016) suggested that even if socioeconomically privileged students tend to have superior performance when extrinsic measures are applied, those from disadvantaged backgrounds could achieve similar or even better results with a greater level of effort and dedication.

Hence, this study will examine whether effort may compensate for the outcome inequalities faced by disadvantaged groups (Lefranc et al., 2008), as well as how this may vary among individuals. The relevant research question is established as follows:

Q4: Does effort have a greater impact on low-SES students' academic achievement than high-SES students?

3. Data and Variables

3.1 Data Source

I leverage panel data from the China Education Panel Survey (CEPS 2013, 2014). The data was collected using a stratified, multi-stage, probability-proportional to size sampling method. Moreover, this dataset comprises information on approximately 30,000 students from 112 schools in 28 provinces, which is nationally representative. To construct the estimation sample, I drop missing values for all relevant variables and remove extreme values so that outliers do not drive the results. The final sample has a total of 24,974 observations. Detailed summary statistics are presented in Table 1.

3.2 Measures and Summary Statistics

Dependent variable

Academic Achievement. I use students' Chinese, Mathematics, and English total exam scores to measure academic achievement. The data were obtained from official school records to minimize measurement errors that might result from self-reporting. As the summary statistics in Table 1 show, the average score is 236 points (52.4% of the total score of 450 points). I take a log transformation of the total scores to make the distribution more normal and the results easier to interpret. The distribution of log-transformed scores in Figure 1 indicates that a proportion of students scored low grades.

Table 3. Summary statistics

Variable	*Mean*	*SD*	*Min*	*Max*
Academic Achievement (total scores)	236.30	74.40	0	440
Log (total score)	5.40	0.38	1.79	6.09
Effort				
Subjective effort (high=1)	0.24	0.43	0	1
Objective effort (hours of study time)	9.83	3.01	0	16
Family SES				
High-SES	0.28	0.45	0	1
Family income	2.81	0.60	1	5
Parental education level	4.15	2	1	9

Controls

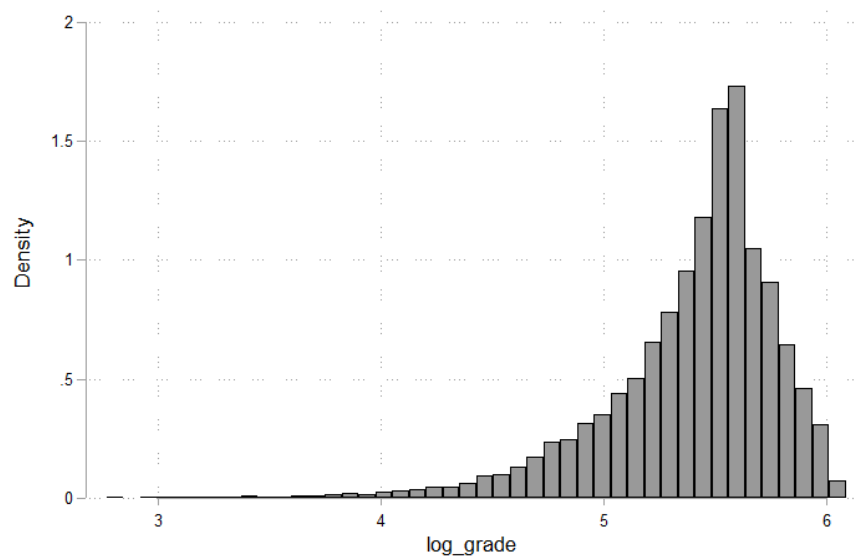|				
Gender (female=1)	0.48	0.51	0	1
Family structure (non-only child=1)	0.56	0.52	0	1
Health	4.14	0.87	1	5
Household registration type (urban=1)	0.46	0.49	0	1
Cognitive skills (cognition test scores)	13.90	8.13	0	35
Parental educational expectation	6.96	1.58	1	9
Student educational expectation	6.89	1.76	1	9
N	24,974			

Fig. 1 Log (total scores)

Key independent variables

Subjective effort. To measure subjective effort, I extract information from three students' self-reported questions concerning their perceptions of effort: "I would try my best to go to school even if I was not feeling very well or I had other reasons to stay at home," "I would try my best to finish even the homework I dislike," and "I would try my best to finish my homework, even if it would take me quite a long time." These three categorical variables share the same Likert scale varying from 1 (Strongly disagree) to 4 (Strongly agree). Higher values imply a higher level of perceived effort. The indicator *subjective effort* would equal 1 if the student demonstrated a high level of perceived effort by answering 4 (Strongly agree) to all three questions and 0 otherwise. 24.4% of students reported strong agreement with three effort-related questions, indicating a high level of subjective effort.

Objective effort. Similar to previous research (Van de Pol et al., 2015), I use the average daily learning time spent by the students, both in and outside of school hours, as a measure of objective effort. On overage, students spent 9.8 hours per day on studies.

Family SES. Two proxies capture family SES: family income (1=Very poor to 5=Very rich) and parental education level (1=None to 9=Master's degree or higher). Xing et al. (2021) noted that, in China, education carries high prestige, while family income grants material privileges and authority. Thus, I construct an indicator of SES based on family income and parental education. *High-SES* is defined as a value of 1 if the student's family income is 4 (Somewhat rich) or greater or if the student's parental education level is 7 (Junior college degree) or higher. Otherwise, the value will be set to 0. Following this definition, 27.9% of students come from a high-SES family with parents who are college-educated or economically rich.

Control variables

Basic demographics. I set the following demographic variables as control variables: gender (Male=0, Female=1), family structure (Only child=0, Non-only child=1), health condition (1=Very poor to 5=Very Good), and house registration type (Rural=0, Urban=1). Summary statistics regarding all the variables are presented in Table 1. 51.8% of the sample is male students, and 48.2% is female students. 56% of the students have siblings.

Cognitive skills. Cognitive skills are essential for learning and academic success and are typically measured by gauging the number of questions students answer correctly on cognitive ability tests (Kautz et al., 2014). Higher scores on these tests indicate higher cognitive ability levels. In this study, CEPS administered a cognitive ability test of 35 questions to the sampled junior high school students. On average, the students correctly answered 14 out of the 35 questions.

Educational expectation. The (student and parental) educational expectations are important academic achievement predictors and could potentially affect students' effort. The educational expectations were measured by asking both students and parents to select one of 9 categories, ranging from dropping out of junior high school (=1) to obtaining a doctoral degree (=9). According to Table 1, the expectations of both parents and students are very similar.

3.3 Correlation Matrix

Table 2 presents the correlation matrix for all variables. While correlation does not necessarily imply causation, it does reveal patterns that are of interest to us. The matrix shows that test scores positively correlate with both subjective and objective effort. On average, students who put in a more subjective effort achieve 12.7% higher scores than those who put in less effort. Furthermore, increasing study time by 1 hour is associated with a 3% increase in scores.

In addition, *High-SES* is positively correlated with test scores, with a correlation coefficient of 18.8%. This indicates a strong relationship between SES and educational outcomes. *High-SES* is also highly correlated with both *family income* and *parental education*, suggesting that it captures a great deal of the variation in these factors. *High-SES* negatively correlates with both subjective effort (corr coef=-0.03) and objective effort (corr coef=-0.60), implying that students from higher-SES backgrounds are 3% less likely to exert subjective effort and spend 0.6 hours less on studies daily.

Overall, the correlation analysis indicates a positive relationship between effort and educational achievement, a positive correlation between family SES and test scores, and a negative correlation between family SES and effort. In the next section, I will employ more rigorous econometric methods to deepen our understanding of these relationships.

Table 2 Correlation matrix

	Log (total score)	Subjective effort	Objective effort	High-SES	Family income	Parental education	Gender	Family structure	Health	Household	Cognitive skill	Parental expectation	Student expectation
Log (total score)	1												
Subjective effort	0.127	1											
Objective effort	0.0308	0.3170	1										
High-SES	0.188	-0.0381	-0.6017	1									
Family income	0.119	-0.0181	-0.0146	0.376	1								
Parental education	0.232	-0.0429	-0.0642	0.729	0.252	1							
Gender	0.185	0.0768	0.0473	0.00430	0.0101	0.00220	1						
Family structure	-0.159	-0.0393	-0.0431	-0.322	-0.185	-0.383	0.0784	1					
Health	0.0686	0.0774	0.00210	0.0931	0.129	0.112	-0.0164	-0.0960	1				
Household	0.161	0.0214	0.0607	0.384	0.198	0.448	0.0118	-0.389	0.0838	1			
Cognitive skill	0.224	0.0549	0.272	0.123	0.0845	0.162	-0.00940	-0.116	0.0788	0.109	1		
Parental expectation	0.410	0.112	0.0390	0.196	0.0683	0.241	0.0527	-0.121	0.118	0.132	0.156	1	
Student expectation	0.368	0.128	0.0479	0.185	0.0768	0.216	0.0641	-0.125	0.0599	0.137	0.160	0.493	1

4. Empirical Design

4.1 Does student effort positively affect academic achievement?

In this sub-section, I use various strategies to examine the causal effect of effort on academic achievement. In the last section, the correlation matrix reveals that subjective and objective effort positively correlates with learning results. Nevertheless, the simple correlation suffers from omitted variable bias. Any potential confounding variables would prevent us from obtaining causal impacts of effort. For example, students in a good class have better teaching resources and thus perform better (Burke & Sass, 2013). At the same time, students in a good class usually have stronger peer effects and are more willing to put effort into their studies. Hence, regressions without controlling for class fixed effects would be biased. To reduce the risk of bias, I first use OLS and control for student characteristics and class-year fixed effects. In my preferred model, I employ a student-fixed effects model by controlling for student and class-year fixed effects. I also use a random effect model as a robustness check.

The complete estimation model is:

$$\log{(total\ scores)}_{ict} = \beta Effort_{ict} + \gamma_{ct} + \delta X_{ict} + \alpha_i + \varepsilon_{ict} \qquad (1)$$

Where $\log(total\ scores)_{ict}$ is log of the total score of student i in class c in year t. As detailed above, I measure a student's effort by two proxies *subjective effort* and *objective effort*. γ_{ct} is class-year fixed effects which captures test difficulty, grading criterion, teaching quality, and other common factors shared by their peers. X_{ict} is a vector representing other control variables as introduced in the previous section. α_i is the student fixed effects which captures all time-invariant characteristics of students. Controlling for students' fixed effects allows us to leverage within-student variations from 2013 to 2014 to isolate the causal effect of effort.

Table 3 presents all the estimation results. In model 1, I include all the controls and class-year fixed effects and performed OLS estimation. The estimated coefficient of *subjective effort* is 0.047 (std.err=0.003), suggesting that students with high subjective effort on average achieve 4.7% higher scores than observed similar students who exhibit low subjective effort. The difference is statistically significant at the 0.1% level. In model 2, I include both objective and subjective measures of effort and employed the same estimation method as in model 1. The coefficient of *subjective effort* (0.044 with a standard error of 0.003) is similar to the estimate in model 1. The coefficient of *objective effort* is 0.02 (std.err=0.001), which means spending 1 more hour on studies is associated with a 2% increase in academic performance. It should be noted that those estimates may not have a causal interpretation.

In models 3 and 4, I further include student-fixed effects. The estimated effect of subjective effort is reduced from 0.044 (std.err=0.003) in model 2 to 0.035 (std.err=0.003) in model 4, suggesting that model 2 overestimates the true effect of subjective effort due to omitted variable bias. After controlling for student fixed effects, the estimates reveal that students who improve (lower) their subjective effort from 2013 to 2014 on average have a 3.5% increase (decrease) in test scores. In model 4, the effect of objective effort remains as 0.02 (std.err=0.001) as in model 2. Increasing the study time by 1-hour leads to a 2% increase in test scores. I also specify a random effect model in the last two columns. The estimated coefficient of *subjective effort* is 0.037 (std.err=0.004), ranging between the OLS estimate of 0.044 (std.err=0.003) and FE estimate of 0.035 (std.err=0.004). The effect of objective effort is 0.03, slightly higher than OLS and FE results. Different model specifications lead to a similar conclusion: effort matters for academic performance, and its effect size is non-negligible.

While the primary focus is on the causal effects of effort and not on the model fit, R^2 can still provide insight into the factors that explain variation in test scores. In model 2, all included covariates and class-year fixed effects explain 63.7% of the variation in students' academic achievements. Including class-year fixed effects absorbs much of the total variation, suggesting that environment (class)

matters for academic success. If further including student fixed effects in model 4, the R^2 becomes 94.6%. Almost all the variation in scores can be explained by time-invariant student characteristics and the environment (class).

Table 3 also uncovers meaningful relationships between several control variables and academic achievement. For instance, in Model 1, the coefficient of gender is 0.105 (std.err=0.003), indicating that female students, on average, score 10.5% higher than their male counterparts after controlling for the gender gap in effort. This may be due to various factors, such as differences in learning styles or socialization practices (Lau et al., 2010). Furthermore, living in urban areas and belonging to a multi-child family have no significant impact on school performance. Moreover, both parental and student expectations are positively correlated with test scores, with a coefficient of 0.04 (std.err=0.001) and 0.02 (std.err=0.001), respectively, in Model 1, in line with previous research (e.g., Xia, 2020).

Table 3 underscores the importance of cognitive skills as a predictor of test scores as well. In Model 1, its estimated coefficient is 0.021 (std.err=0.001), indicating that students with high cognitive abilities achieve higher exam scores. Specifically, a 1-point increase in cognition test scores is associated with a 2.1% increase in academic test scores. This finding is consistent with previous research highlighting the effect of cognitive skills on academic achievement, where it serves as the foundation for knowledge acquisition and learning (e.g., Pellegrino & Hilton, 2012).

Table 3 Regression estimates of effort on academic achievements

	(1)	(2)	(3)	(4)	(5)	(6)
Model	OLS	OLS	FE	FE	RE	RE
Dep Var: Log (total scores)						
Subjective effort (high=1)	0.047***	0.044***	0.036***	0.035***	0.039***	0.037***
	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)

Objective effort		0.02***		0.02***		0.03***
		(0.001)		(0.001)		(0.001)
Gender (female=1)	0.105***	0.107***			0.123***	0.126***
	(0.003)	(0.003)			(0.005)	(0.005)
Family structure	-0.003	-0.003			0.062***	-0.060***
	(0.004)	(0.004)			(0.005)	(0.005)
Health condition	0.000	0.001	0.001	0.001	0.004	0.003
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Household registration type	-0.002	-0.003			0.034***	0.033***
	(0.004)	(0.004)			(0.004)	(0.004)
Cognitive skills	0.021***	0.021***	0.003***	0.003***	0.014***	0.015***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Parental educational expectation	0.044***	0.043***	0.011***	0.011***	0.041***	0.041***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Student educational expectation	0.028***	0.028***	0.000	0.001	0.022***	0.023***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Class-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Student FE	No	No	Yes	Yes	No	No
N	24974	24974	24974	24974	24974	24974
R^2	0.634	0.638	0.947	0.946	-	-

Note: This table provides the results of six different models (1-6) that estimate the relationship between various independent variables and the dependent variable "Log (total score)." Models 1 and 2 are pooled OLS models. Models 3 and 4 are student fixed effects (FE) models. Models 5 and 6 are random effects (RE) models. Standard errors, shown in parentheses, are clustered at the class level.

$^{*}\,p < 0.05,\,^{**}\,p < 0.01,\,^{***}\,p < 0.001$

4.2 Does Family SES have greater impact than effort on academic achievement?

Effort positively affects students' academic achievements, but it does not mean effort is more important than family background in impacting their performance. In this sub-section, I investigate which matters more, effort or family SES.

Table 4 summarizes the relative contribution of effort or family SES variables in the regression to the overall model fit. In the baseline model, the log of total scores is regressed on all controls and class-year fixed effects, yielding an R^2 of 0.620. Adding measures of subjective and objective efforts in model 2 increases the R^2 by 0.018 (2.9%) relative to the baseline model. Model 3 further includes family SES proxies (family income and parental education level), which increases the model fit by 0.044 (7.1%). This exercise suggests that including family SES explains more variation in student academic performance than including effort.

An alternative approach to examine which factor is more important is to compare their effect sizes. However, since these factors are measured using different scales, direct comparison is not feasible. I thus normalize all variables to enable comparability. In Table 5, the normalized log of total scores is regressed on the normalized effort, family SES, and other control variables. Results reveal that the family SES proxies have a larger effect size than effort measures.

These findings suggest that family SES is crucial in determining academic success and that effort alone may not suffice in overcoming the barriers faced by low-SES students, which aligns with Golley & Kong (2018). However, this does not imply that effort is inconsequential, and students from low-SES families could not profit from putting more effort into learning. In the following sub-sections, I will examine whether low-SES students work harder and whether increased effort could help bridge the achievement gap.

Table 4 Relative contribution of effort *vs*. family SES to academic achievement

	(1)	(2)	(3)
Dep Var: Log (total scores)			
Predictors	Baseline controls	Baseline controls + Effort measures	Baseline controls + SES proxies
R^2	0.620	0.638	0.664
R^2 increase relative to baseline	-	0.018 (2.9%)	0.044 (7.1%)

Note: The respective incremental adjustments to R^2 demonstrate the relative importance of effort measures and family SES proxies. Model 1 only includes controlled variables (as detailed in Table 1) with a class-year fixed effect, while Model 2 further includes effort measures (objective and subjective effort), and Model 3 further adds SES proxies (family income and parental education level).

Table 5 Comparative effects of effort and family SES on academic achievement

	(1)	(2)
Dep Var	Standardized log (total score)	Un-standardized log (total score)
Standardized variable		
High subjective effort	0.117***	
	(0.000)	
Objective effort	0.013*	
	(0.022)	
Family income	0.139***	
	(0.000)	

Parental education level	0.211***	
	(0.000)	
Un-standardized variable		
High-SES		0.101***
		(0.000)
Controls	Yes	Yes
Class-Year FEs	Yes	Yes
N	24974	24974
R^2	0.674	0.659

Note: Controlled variables are detailed in Table 1. Standard errors, presented in parentheses, are clustered at the class level.

$^{*} p < 0.05$, $^{**} p < 0.01$, $^{***} p < 0.001$

4.3 Do students from disadvantaged backgrounds exhibit greater effort than their more privileged peers?

To investigate the effect difference between high-SES and low-SES students, I estimate the following model:

$$\text{Effort}_{ict} = \beta high\ SES_{ict} + \gamma_{ct} + \delta X_{ict} + \varepsilon_{ict} \tag{2}$$

The variable of interest is $high\ SES_{ict}$, which takes a value of 1 if the student comes from a high SES family, and 0 otherwise. I also include class-year fixed effects γ_{ct} and other controls X_{ict}. Student-fixed effects cannot be included since students' family SES status rarely changes within such a short

timeframe. If student effort is measured by a binary variable (*subjective effort*), a linear probability model (LPM) is used, and if effort is measured by the length of working time, an OLS model is estimated.

Table 6 reports the estimation results. In the LPM, the coefficient of the *High-SES* is -0.073 (std.err=0.001), suggesting that high-SES students are 7.3% less likely to be in the high subjective effort group than low-SES students. A similar pattern can be observed in model 2, where the coefficient of the *High-SES* is -0.902 (std.err=0.005). On average, students from high-SES backgrounds spend 0.9 fewer hours on their studies than observably comparable students from less privileged families. The R^2 values for Model 1 and Model 2 are 0.299 and 0.313, respectively, suggesting that circumstances (family and school) only explain around 30% of the variation of students' effort and that probably a larger proportion of variation in effort might be explained by individual traits.

Table 6 shows that low-SES students exert more effort in their studies than their high-SES peers. In China, this trend could be attributed to high parental and student aspirations for tertiary education (Wei et al., 2019), sociocultural values emphasizing the importance of "hardship and hard work" (Li, 2010), and the intense pressure created by the highly competitive high school admissions process (Hansen & Woronov, 2013). Under such circumstances, students from disadvantaged backgrounds may feel compelled to achieve more and surpass their "usual" effort level to be more competitive.

Table 6 Regression estimates of the relationship between effort and family SES

	(1)	(2)
Model	LPM	OLS
	Subjective effort	Objective effort
High-SES	-0.073***	-0.902***
	(0.001)	(0.005)

	(0.002)	(0.012)
Controls	Yes	Yes
Class-year FE	Yes	Yes
N	24974	24974
R^2	0.299	0.313

Note: Controlled variables are detailed in Table 1. Standard errors, reported in parentheses, are clustered at the class level.

$^* p < 0.05,$ $^{**} p < 0.01,$ $^{***} p < 0.001$

4.4 Does effort have a greater impact on academic performance for low-SES students than for high-SES students?

In this sub-section, I will explore two approaches to investigate whether effort could potentially narrow the achievement gap between high-SES and low-SES students. The first approach involves running an interaction effect model, as shown below:

$$\log{(total\ scores)}_{ict} = \beta_1 Effort_{ict} + \beta_2 Effort_{ict} \times High\_SES_i + \gamma_{ct} + \delta X_{ict} + \alpha_i + \varepsilon_{ict} \quad (3)$$

Where β_1 captures the effect of effort on test scores for low-SES students, and β_2 captures the effect difference for high-SES students compared with low-SES students. $High\_SES_i$ is absorbed by student fixed effect and cannot be separately estimated. The remaining terms are same as equation (1).

Table 7 presents the differences. In column 1, the interaction between *subjective effort* and *High-SES* is negative (coef=-0.024, std.err=0.015), meaning that compared with low-SES students, exerting high subjective effort leads to 2.4% fewer scores in tests relative to exerting low effort. In column 2, the

interaction between *objective effort* and *High-SES* is also negative (coef=-0.037, std.err<0.000). The marginal effect of learning time on scores is 3.7 % less for high-SES students. These results prove that increased effort has a larger impact on low-SES students.

Table 7 Effects of effort on academic achievement between low-SES and high-SES groups

	(1)	(2)
Dep Var: Log (total scores)		
Subjective effort	0.035***	
	(0.000)	
Objective effort		0.016***
		(0.000)
Subjective effort × High-SES	-0.024*	
	(0.015)	
Objective effort × High-SES		-0.037***
		(0.000)
Controls	Yes	Yes
Class-Year FE	Yes	Yes
Student FE	Yes	Yes
N	24974	24974
R²	0.908	0.899

Note: The coefficient of High-SES is absorbed by student FE and therefore not presented in the table. Controlled variables are detailed in Table 1. Standard errors, indicated in parentheses, are clustered at the class level.

$^{*}\,p<0.05,\ ^{**}\,p<0.01,\ ^{***}\,p<0.001$

For the second approach, I divide the students into two groups based on their family SES status: high-SES and low-SES. Within each group, I further classify students into four sub-groups based on their subjective effort levels in 2013 and 2014. The four sub-groups are: 1) consistently low effort, 2) consistently high effort, 3) decreased effort, and 4) increased effort. For students in each sub-groups, I obtain the 95% confidence interval for the academic performance change: log (total score in 2014)/log(total score in 2013). This exercise allows for a granular examination of the differences in effort level over time between high-SES and low-SES students.

Table 8 displays the percentage of students in each sub-group and their corresponding interval estimates of total score changes. Most students in 2014 maintained their effort status from 2013, with 72.9% of high-SES students and 69.9% of low-SES students remaining in the same effort category. Notably, a higher proportion of low-SES students progressed in their effort level compared to high-SES students, with 19.9% of low-SES students working harder in 2014 compared to 13.7% of high-SES students. Moreover, a smaller proportion of low-SES students transitioned from high-effort status to low-effort status (10.1%) compared to high-SES students (13.4%). This observation echoes our previous finding that students from low-SES backgrounds tend to work harder.

The second and most important observation based on Table 8 is that effort matters more for low-SES groups. Focusing on those who switched their effort status (last 2 columns), the test scores change by [-1.7%, -0.1%] for high-SES students who lowered their effort level, but change by [-5.7%, -4.0%] for low-SES students who worked less hard. Similarly, the test scores change by [1.3%, 2.0%] for high-SES students who improved their effort level and change by [2.8%, 3.3%] for low-SES students who put more effort into their studies. These comparisons suggest that effort matters more for low-SES students. If low-SES students work harder, they enjoy a larger marginal effect in scores than high-SES

students. However, if they shirk, their academic performance will decline to a larger degree than high-SES students.

Table 9 shows similar exercises for objective effort (hours of study time). Since working time is a continuous variable, I divide students into 2 groups based on whether they spent more or less time studying in 2014 compared to 2013. The pattern is similar: 1) more students in the low-SES group spent more time in studies in 2014, and 2) the marginal effect of effort is larger for low-SES students. If students decreased their study time, the test score would be changed by [-4.7%, -4.1%] for low-SES students, but the score remained unchanged for high-SES students as the 95% CI [-0.6%, 1.0%] cross 0. One possible explanation is that high-SES students may have other resources or better time management skills to compensate for the reduced study time (Bacher-Hicks et al., 2021; Chiu & Chow, 2015).

To summarize, students from high-SES families tend to exert a lower level of subjective effort or spend less time studying, but this does not significantly affect their academic performance. In contrast, students from low-SES families who exert more subjective effort or spend more time studying experience a substantial increase in academic achievement, demonstrating that effort is particularly crucial for those from disadvantaged backgrounds. Although students from low-SES families may face additional barriers, such as limited access to educational resources, socioeconomic pressures, or a lack of family and community support compared to their high-SES peers (Liu, 2019), they can still attain academic success with unwavering effort, even in the face of adversity.

Table 8 Within-student decomposition regarding changes in subjective effort from 2013 to 2014

		Low effort → Low effort	High effort → High effort	High effort → Low effort	Low effort → High effort
High-SES students	% of students (95% score increase CI)	66.4% (-0.7%, 0.3%)	6.5% (-1.0%, 1.1%)	13.4% (-1.7%, -0.1%)	13.7% (1.3%, 2.0%)
Low-SES students	% of students (95% score increase CI)	64.9% (-1.3%,0.8%)	5.0% (-0.4%, 1.3%)	10.1% (-5.7%, -4.0%)	19.9% (2.8%, 3.3%)

Note: The 95% CIs are confidence intervals for total score improvement from 2013 to 2014. For example, the 95% CI for low-SES students who had a low effort in 2013 but had a high effort in 2014 is (2.8%, 3.3%), meaning that those students' test score increases by 3.05% ((2.8+3.3)/2) with a CI (2.8%, 3.3%) from 2013 to 2014.

Table 9 Within-student decomposition regarding changes in objective effort from 2013 to 2014

		Hours of study time *increase*	Hours of study time *decrease*
High-SES students	% of students (95% score increase CI)	56.8%	43.2%
		(2.1%, 2.6%)	(-0.6%, 1.0%)
Low-SES students	% of students (95% score increase CI)	62.6%	37.4%
		(2.9%, 3.8%)	(-4.7%, -4.1%)

Note: The 95% CIs are confidence intervals for total score improvement from 2013 to 2014. For example, the 95% CI for low-SES students who spent an increase in working time relative to last year is (2.9%, 3.8%), meaning that those students' test score increases by 3.35% ((2.9+3.8)/2) with a CI (2.9%, 3.8%) from 2013 to 2014.

5. Conclusions

This study demonstrates that student effort has a meaningful influence on academic achievement. Results also showed that family SES indeed has a greater impact on academic success than student effort. However, this does not suggest that effort should be disregarded or that students from low-SES backgrounds cannot improve their performance through hard work. These findings highlight the ongoing educational inequalities and the necessity for targeted interventions for low-SES students. Additionally, it was found that low-SES students exert more effort than their high-SES peers and benefit more from the increased effort, as it results in a larger improvement in academic performance. This emphasizes that increased effort can help to level the educational playing field for low-SES students and that family SES should not be perceived as an insurmountable barrier to academic success. Furthermore, it was also discovered that decreased effort has a larger negative impact on the performance of low-SES students. This further indicates that it is crucial to emphasize the potential of utilizing student effort as an intervention to facilitate equitable educational outcomes for those from disadvantaged backgrounds.

These findings have important implications for policymakers. Some strategies particularly addressed to students from low SES families might include:

(1) Providing awareness about the importance of the effort to help students to recognize the value of their hard work;

(2) Providing resources for disadvantaged students, such as tutoring, homework help centers, and after-school study programs to help them to increase their working time;

(3) Offering parental support and education to parents from low SES backgrounds on how to improve their children's learning effort.

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Additionally, it is important to acknowledge the potential limitations of relying on self-reported effort measures, as participants may not accurately report their effort due to factors such as social desirability bias, memory bias, or lack of self-awareness. As such, the results of this study should be interpreted with caution and considered within the specific context of the study. Longitudinal studies with more expansive data and research conducted in other cultures and countries are necessary to increase the external validity of the results.

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Study III

Predicting Academic Success: Machine Learning Analysis of Student, Parental, and School Efforts

The complete bibliographic information of this publication is:

Jin, X. (2023). Predicting academic success: machine learning analysis of student, parental, and school efforts. *Asia Pacific Education Review*, 1-22. https://doi.org/10.1007/s12564-023-09915-4

Abstract

Understanding what predicts students' educational outcomes is crucial to promoting quality education and implementing effective policies. This study proposes that the efforts of students, parents, and schools are interrelated and collectively contribute to determining academic achievements. Using data from the China Education Panel Survey conducted between 2013 and 2015, this study employs four widely used machine learning techniques, namely, Lasso, Random Forest, AdaBoost, and Support Vector Regression, which are effective for prediction tasks—to explore the predictive power of individual predictors and variable categories. The effort exerted by each group has varying impacts on academic exam results, with parents' demanding requirements being the most significant individual predictor of academic performance; the category of school effort has a greater impact than parental and student effort when controlling for various social-origin-based characteristics; and significant gender differences among junior high students in China, with school effort exhibiting a greater impact on academic achievement for girls than for boys, and parental effort showing a greater impact for boys than for girls. This study advances the understanding of the role of effort as an independent factor in the learning process, theoretically and empirically. The findings have substantial implications for education policies aimed at enhancing school effort, emphasizing the need for gender-specific interventions to improve academic performance for all students.

Keywords: Academic Achievement , Machine Learning, School Effort , Family Involvement, Gender Disparities

1. Introduction

The literature has established that the academic achievements of students are influenced by the efforts exerted by the agents involved in the education process, namely, the school attended, the parents lived with, and the students. Despite the importance of effort, research on educational achievement has not adequately investigated the role of effort as an independent input in the education process, theoretically and empirically. Although student effort (e.g., subjective perceived effort, objective time spent learning) plays a crucial role in educational outcomes, parental effort (e.g., family involvement, parents' interest in their children) and school effort (e.g., classroom instruction, school management) are also vital (Gamboa & Waltenberg, 2012; Edmark & Persson, 2021; Golley & Kong, 2018; Broer & Bai, 2019; Dietrich et al., 2021). However, not every effort is equally important in achieving the desired outcomes. Notably, the literature has not investigated each effort's relative importance in explaining academic achievements.

This study aims to answer two questions: what is the relative importance of the individual effort variables in explaining academic achievements, and because some fields of influence appear more critical than others in predicting the outcome variable (Adler et al., 2018), what is the collective importance of these fields of influence. These answers will demonstrate the relative contribution of the effort variable group, which comprises school effort, parental effort, and student effort, in explaining the academic achievements.

To answer these questions, I use the China Education Panel Survey 2013−2015, a rich dataset that follows a cohort of sampled students throughout their junior high school years. The data are collected through comprehensive questionnaires completed by students in 7th and 9th grades, providing detailed information on their attitudes toward school and education. To construct measures of effort exerted by the different agents in the education process, I use a range of indicators. For students, I use self-reported

answers to questions such as their reported time spent studying and their motivation to set and work toward academic goals. For parents, I examine their level of involvement in their children's education, such as whether they supervise their child's homework or frequently attend meetings with teachers. To capture the level of effort exerted by schools in the education process, I adopt 15 constructed effort variables, such as the implementation of interventions that support academic growth and development by the school, the availability of academic guidance services for students, and the type of disciplinary methods employed by the school's administration.

However, the empirical challenge is selecting economically and statistically significant effort variables that predict academic achievements among an adequate number of potential predictors. Traditional statistical methods techniques such as least squares regression (OLS) are limited in achieving accurate variable selection and good out-of-sample performance, especially when the number of regressors is large (Steyerberg & Harrell, 2016). Furthermore, the complex interplay between effort variables and academic performance might not be captured by parametric assumptions (Roick & Ringeisen, 2017), necessitating the use of estimation techniques that offer enhanced flexibility.

Machine learning techniques are ideal for addressing these challenges and answering this paper's two research questions. These techniques select influential features and model complex relationships between input variables and outcomes (Takeda et al., 2013). They are also ideal for managing high-dimensional data with many predictors while avoiding overfitting, a common problem in traditional statistical methods. In this study, I leverage four state-of-the-art machine learning tools—Lasso, Random Forest, AdaBoost, and Support Vector Regression (SVR)—to predict which individual effort variable or effort group is most predictive of academic performance. Lasso is a widely used regularization regression method for variable selection, which helps identify the most relevant effort variables. The remaining three methods model nonlinear relationships, which is crucial because of the complex interplay among varying effort variables and academic performance. Additionally, these methods rank

variables by their prediction power, providing intuitive comparisons of the relative importance of different effort variables. Overall, using machine learning techniques, I perform a comprehensive analysis of many potential predictors and identify the most relevant effort variables for predicting academic achievement.

To assess the relative importance of each effort variable, I employ the aforementioned machine learning algorithms, using all 45 effort variables and 15 controlled variables to predict academic performance. I identify the top 20 most important effort variables based on the coefficient magnitudes in Lasso and SVR, SHapley Additive exPlanations (SHAP) value in Random Forest, and importance score in AdaBoost. Among the top 20 predictors, most variables relate to school effort and parental effort, and some variables relate to student effort. Parents' demanding requirement is the most significant predictor among all individual variables. Furthermore, students' and parents' educational expectations exert a greater influence on academic achievements than other factors do. The practice of inviting parents to school events is the third most predictive factor for students' grades. These results indicate that if parents and schools prioritize education and highly value academic achievement, they may be more likely to provide a supportive (both at home and school) environment and encourage students' academic pursuits (Gbollie & Keamu, 2017).

To assess the importance of effort-related group variables, I include school effort, parental effort, and student effort variables independently in the model to predict academic performance. The results indicate that "school effort" is the most influential predictor of academic achievement, followed by parental effort, and students' effort has a limited impact. These findings underscore the crucial role of a supportive school environment, namely, school events and teacher supervision, in promoting academic success (Park et al., 2017). Furthermore, the heterogeneity test between male and female students finds that for girls, school effort has a greater impact on academic achievement than parental effort does; the opposite is true for boys. Thus, particularly in China, where parental investments often favor boys in

multi-children families (Ling, 2017), girls who receive more attention and financial incentives from schools and teachers can be more equipped to navigate these changes and achieve academic excellence (Tang & Horta, 2021). These findings suggest that gender-specific interventions and support programs are necessary to improve academic outcomes for girls during the critical period of intellectual and academic development of junior high school.

Methodologically, this study contributes to the understanding of the relative contribution of multiple variables to students' academic achievements by using modern machine learning models (Masci et al., 2018). Traditional statistical models may provide biased results due to the unknown functional form of how effort affects grades, potential interactions between effort variables, and collinearity. By contrast, machine learning techniques offer flexibility, feature selection, model validation, and robustness to multicollinearity (Ogutu et al., 2012). Thus, the machine learning approaches in this study obtain good out-of-sample prediction accuracy by selecting relevant variables and reducing overfitting (Dalalyan et al., 2017). This strategy provides a feasible and superior approach to narrowing outcome predictors, especially in the case of large high-dimensional databases in educational research. The ability to accurately predict unequal educational outcomes deepens the understanding of the effort-related factors that drive educational success and clarifies a strategic direction for additional compensation and policy intervention.

The findings of this study contribute to the literature by providing empirical evidence for the theoretical prediction that differences in how parents, schools, and students perceive and act in achieving higher academic performance can lead to disparities in academic outcomes (e.g., Edossa et al., 2018). This study emphasizes that academic success is not solely determined by objective structural factors, such as family background and school resources (Berkowitz et al., 2017) but also by latent motivation and tangible action efforts (Gneezy et al., 2019). As such, this study underscores the importance of increasing the effort to improve academic results and highlights the necessity to stimulate effort as a

more feasible and effective approach than modifying social background or school resource allocation (Yeager & Dweck, 2012).

The identification of school effort as the most significant predictor of academic success has critical policy implications. Policymakers can focus on promoting various forms of school effort, such as creating a supportive and positive learning environment, providing individualized tutoring for students, encouraging teacher supervision, and enhancing student and parental participation in school events. By prioritizing school effort, policymakers can more effectively improve academic achievement than by relying solely on material resources or higher-quality teaching faculty and facilities.

The paper is organized as follows. The theoretical backgrounds are illustrated in Section 2, and the data source and variables are briefly introduced in Section 3. The methodology includes benchmark methods, feature extraction principles, and machine learning techniques and is presented in Section 4. The relevant results and discussions are elaborated in Section 5. The conclusion and potential policy implications are provided in Section 6.

2.   Theoretical Background

Sociologists have long been concerned with the extent to which inequality of opportunity, caused by circumstantial factors and family endowment, contributes to inequality of outcomes. Blau and Duncan (1967) were the first to establish a dual-driven theoretical model of family resource investment and self-motivated effort from a micro perspective. They proposed the status attainment model, using path analysis to explore the extent to which the occupational attainment of the population in the United States is influenced by their family background and level of education at the micro-level (Ganzeboom et al., 1991; Winship, 1992). They regarded an individual's academic status attainment as the result of multiple factors that emerge sequentially throughout their life cycle; thus, they developed a pathway model

incorporating innate and self-induced elements and inter-and intra-generational mobility into the analysis.

Although the classical status attainment model has been developed from structural and psychosocial perspectives, this study argues that several concerns are still worth discussing and expanding. Drawing on Bourdieu's (1984) theory of habitus and cultural capital, and Baumrind's (1971), Lareau's (2002), and others' studies of family parenting styles and school effectiveness, effortful devotions, namely, cognitive capacity, non-cognitive motivation, and observable time-devoted, may also be considered unavoidable factors impacting on educational outcomes (Deluca & Rosenbaum, 2001; Guan et al., 2006; Inzlicht et al., 2018; Shenhav et al., 2021). However, status attainment research has mainly disregarded the effort factor, which treats human capital invested in education as an effort factor concerning the family background to explain offspring educational outcomes (Sewell & Shah, 1968; Caldas & Bankston, 1997; Sheldon & Epstein, 2005). Human capital input is not equivalent to the individual effort factor; it primarily serves as a transmission and mediator between paternal and offspring status (Kohn et al., 1990; Bourdieu, 2002). The effects of actual psychological and behavioral efforts as independent exogenous variables and the mechanisms via which they function have not been examined.

To improve the understanding of the actual psychological and behavioral efforts exerted during task performance, Steele's (2020) framework on effort, which distinguishes between objective and subjective effort, offers valuable insights. Steele (2020) defined "objective effort" as tangible and measurable actions that reflect the amount of energy or work invested in a task, and "subjective effort" encompasses intangible internal experiences and attitudes associated with a task or goal. To operationalize effort in the context of this study, I adopt Steele's (2020) definition of effort. In this study, effort is examined at the individual student level, and at the level of parents and schools. Specifically, students' effort can be observed in how they approach education broadly, how they respond to classroom interactions with teachers, how much time they dedicate to and how much motivation they have for

learning, how much inspiration they receive from family, how they conduct the necessary tests, and some other objective and perceived effort exerted to meet academic needs (Dunlosky et al., 2020, Mudrak et al., 2021). Similarly, by viewing "parents" and "schools" as behavioral agents in the same manner as individual students, their efforts to improve students' educational outcomes during the task can also be defined as objective and subjective efforts rather than solely focusing on educational investment behaviors. These efforts can include psychologically devoting attention, stimulating motivation, instilling a sense of belief, and behaviorally spending additional time and energy on academic tasks (Stables, et al., 2014; Ng, F. F. Y., & Wei, 2020).

These various efforts, shaped by family or school, modify educational behaviors that result in varying levels of academic performance, and increases social status (Burić & Sorić, 2012; Zimmerman, 2013). Efforts and effort-based capability can also supplement outcome disparities caused by structural factors when acting in different directions and with different forces (Darling-Hammond, 2018). If students inherently believe in devoting attention, parents and relevant schools would spend more time and energy on academic tasks, and the student's favorable outcomes would increase. Enhancing students' educational success is challenging, if not inconceivable, if the three key agents do exert the effort, regardless of the student's family background or school quality (Richardson et al., 2012). By taking a more nuanced approach than that in the literature to the role of effort in educational outcomes, understanding how different factors interact to influence student achievement can improve.

Therefore, highlighting the potentiality and capability of efforts to reduce outcome inequalities is rational. The learning motivations and exertions of students, parents, and schools can, to some extent, complement, compensate, and counter structural disadvantages in achieving equal outcomes (Amis et al., 2020; Hirsch, 2019). Additionally, students' acquisition of social and academic status is assuredly an integrated process affected by circumstantial and effort-related factors (e.g., Hodge et al., 2018) and a final collaborative result among efforts of parents, schools, and individuals (De Fraja et al., 2010). The

distinction among the three agents' efforts is more akin to a spectral range than a dividing line; in reality, every action can be determined by a combination of these three components. An overemphasis on the influence of one level of factors at the expense of others may lead to reductionism or ecological fallacy in methodology (Curran & Bauer, 2011). Therefore, a thorough analysis of the three sides must be considered, especially to examine which aspect dominates students' learning progress, resulting in disparities in student achievements under an integrated framework. More specifically, this study aims to determine the extent to which factors can have the most predictive effects on educational outcomes while all three types of efforts are considered simultaneously. The conceptual framework for this study is illustrated in Figure 1, which provides a comprehensive overview of the research progress.
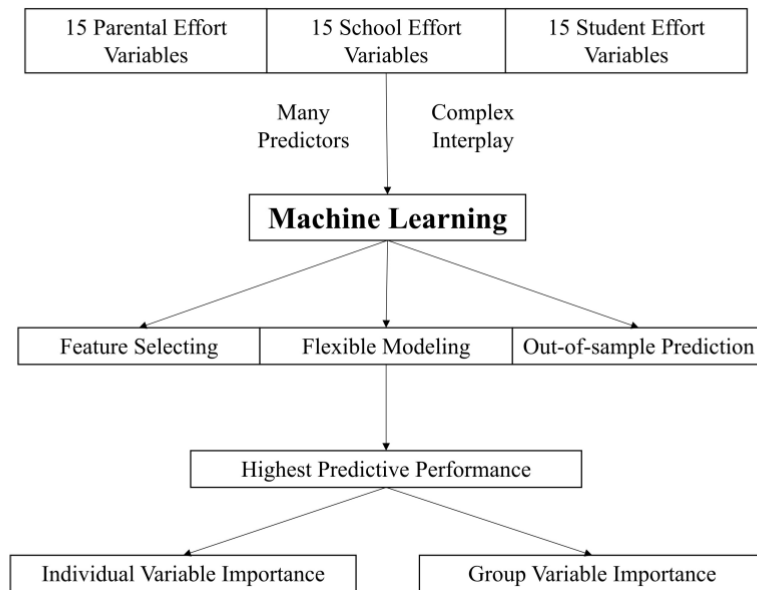

Fig. 2 Conceptualized Framework

3. Data and Measures

3.1 Data Source

This study uses data from the China Education Panel Survey (CEPS), a nationally representative survey designed and implemented by Renmin University in China. The primary aim of the survey is to investigate the impact of various factors, namely, family, school, individual, and macro-social structures, on students' academic achievements. The survey was conducted by selecting a sample of 112 schools, 438 classes, and approximately 30,000 students by using a national sampling method.

The large sample size of the CEPS is a substantial strength of this study because it generates more accurate averages, identifies outliers, and yields reduced margins of error (Wang, 2016), enhancing the external validity of the findings. Moreover, the survey provides detailed information on three key agents' efforts and demographic characteristics, namely, individual innate ability, family background, and school resources, which are essential for understanding the internal and external environments of students (Xu, 2016; Ma & Wu, 2019) and, thus, this analysis.

I drop missing values for all relevant variables and remove extreme values to avoid potential bias from outliers. The final estimation sample comprised 24,974 students' information.

3.2 Measures

Dependent variable

Academic Achievement. To measure academic achievements, I use students' total test scores: the sum of Chinese, Mathematics, and English scores. The data were sourced from the students' term exam scores across two consecutive school years and provided by their respective schools. Table 1 shows that the

average score for these students is 236 points, accounting for 52.4% of the maximum possible score of 450 points.

Predictors

Student effort. Psychological and behavioral efforts play a crucial role in improving educational attainment (Schunk & DiBenedetto, 2020). Therefore, the effort students invest in their academic work is a significant factor influencing their academic achievement. To assess student effort, I use multiple survey measures, namely, students' (1) self-reported time spent studying and completing homework assignments, (2) subjective perception of their effort levels, (3) proactive efforts to seek additional help or resources when needed, (4) motivation to set and pursue academic goals, and (5) engagement in extracurricular activities that promotes academic growth and development. These measures are encoded into categorical variables, with higher values representing a greater level of student effort[2]. I include 15 proxies for student effort.

Parental effort. Parental effort is assessed based on parents' level of involvement and support in their child's education, and their attitudes toward their child's academic performance (Avvisati* et al., 2010). Specifically, this study measures parental effort by using four variables: parents' (1) engagement in their child's studies, (2) willingness to discuss their child's progress with teachers, (3) academic goals and career aspirations for their child, and (4) role in modeling good study habits and time management skills at home. Higher values on these measures indicate a higher level of parental effort in contributing to their child's educational success. I include 15 variables to measure parental effort.

School effort. This study measures school effort by using five indicators related to activities that extend beyond the mandatory requirements of educational institutions (Baños et al., 2019): (1) implementation

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[2] Details on how these variables are constructed are in Table 3 in the Appendices.

of interventions that support academic growth and development; (2) parent and community involvement in school activities and events; (3) provision of academic and life guidance to students; (4) practice of grouping students based on similar abilities; and (5) disciplinary methods employed by schools, such as offering night study sessions or individualized academic tutoring. Higher values on these measures indicate greater school effort in fostering students' academic success. I include 15 school effort variables.

Descriptive Statistics

Table 1 Descriptive Statistics

Variables	*Abbr.*	*Mean*	*SD*	*Min*	*Max*
Academic achievement (total scores)	TotalScore	236.4	74.38	0	440
Student effort					
Time spent studying and completing homework assignments					
Time spent completing in-class homework	StuSchoolHomework	5.617	3.614	0	48
Time spent completing ex-class homework	StuExtraHomework	2.244	2.688	0	48
Time spent attending cram school	StuCramSchool	1.969	2.659	0	48
Self-perceived subjective effort					
Student self-dedication	StuDelication	3.217	0.847	1	4
Student self-persistence	StuPersistence	3.260	0.843	1	4
Student self-resilience	StuResilience	3.273	0.890	1	4
Seeking out additional help or resources when needed					

Attend tuition classes (related to schoolwork) (no = 0, yes = 1)	StuTuition	0.318	0.466	0	1
Participate in summer/winter camps (no = 0, yes = 1)	StuSummerCamp	0.103	0.304	0	1

Setting and working toward academic goals

Student self-expectation	StuExpectation	6.891	1.761	1	10
Student self-confidence	StuFaith	3.176	0.721	1	4

Engaging in extracurricular activities that support academic growth and development

Attend International Mathematical Olympiad (IMO) class	StuOlympiad	0.036	0.187	0	1
Attend extra Mathematics (exclude IMO) class	StuExtraMath	0.214	0.410	0	1
Attend extra Chinese class	StuExtraChinese	0.109	0.311	0	1
Attend extra English class	StuExtraEnglish	0.231	0.421	0	1
Frequency of visits to museums	StuVisitFreq	1.990	1.123	1	6

Parental effort

Engaging in their child's academic growth and development

Help with their child's homework	ParTutoring	2.192	1.142	1	5
Supervise their child's homework	ParMonitor	1.649	1.123	0	4
Frequency of parental visits to museums with their Child's	ParVisitFreq	2.085	1.220	1	6

Communicating regularly with teachers and staying involved in their child's academic progress

Parents talk to teachers about their child's learning	ParCareLearning	0.691	0.462	0	1
Whether parents proactively contact with teachers	ParContactTeacher	2.373	1.020	1	4

Parents' attitudes toward their child's academic performance

Parental discipline for their child	ParDiscipline	0.659	0.474	0	1
Parents enrolling their child in tuition	ParTuition	0.092	0.290	0	1
Parents' concern for their child's effort level	ParPerception	0.857	0.350	0	1

Parents' academic goals and career aspirations for their Child's

Parents' requirements for their child's performance	ParRequirement	3.018	0.858	1	4
Parents' educational expectations for their child	ParExpectation	6.957	1.577	1	9
Parents' faith in their child	ParFaith	3.227	0.689	1	4

Modeling good study habits and time management skills at home

Parents being strict about their child's homework and exams	ParCareExams	2.363	0.532	1	3
Parents being strict about their child's school behaviors	ParCareBehavior	2.283	0.586	1	3

Parents being strict about their child's time spent on the internet	ParBanInternet	2.581	0.566	1	3
Parents being strict about their child's time spent watching TV	ParBanTV	2.361	0.586	1	3

School effort

Implementing supportive interventions that support academic growth and development

School requires students to attend night study	SchNightStudy	1.563	0.715	1	3
Teachers on duty for night study	SchSupervision	0.951	0.216	0	1
School organizes summer/winter camps for students	SchSummerCamp	0.103	0.304	0	1

Supporting teacher professional development and addressing student academic/life needs

Frequency of school sessions on academic/life coaching	SchCoaching	2.251	0.842	1	4
Availability of teacher training	SchTeacherTraining	1	0	1	1
Partnerships with local businesses for additional resources	SchPartnership	0.086	0.281	0	1

Encouraging parent and community involvement in school activities and events

Frequency of parent-teacher meetings	SchParentMeeting	2.628	0.615	1	4
Frequency of written reports from the school to parents	SchWrittenReport	2.769	0.861	1	4
Frequency of schools inviting parents to observe	SchClassReport	2.067	0.893	1	4

Providing effective and engaging classroom instruction

Main teaching methods: teacher-led lectures	SchTeacherLecture	0.925	0.264	0	1
Main teaching methods: group discussions	SchGroupDiscussioon	0.586	0.493	0	1
Main teaching methods: bilingual teaching	SchBilingualTeaching	0.062	0.242	0	1
Main teaching methods: stratified teaching	SchStratifiedTeaching	0.090	0.285	0	1

Offering individualized academic support services such as tutoring or academic counseling

School offers remedial classes for students with failing grades	SchRemedialCourse	1.981	1.367	0	4
School offers advanced study for students good at a single subject	SchImprovedCourse	0.572	0.495	0	1
N	24,974				

Note: Descriptive statistics for the variables used in the pooled ordinary least squares (OLS) and machine learning regression analyses. For brevity, all abbreviations used in the table refer to the aforementioned regression results. Specifically, variable abbreviations with the prefix "Stu-" denotes student effort, "Par-" denotes parental effort, and "Sch-" denotes school efforts. Detailed descriptive statistics of the controlled variables used in the analysis are in Table 4.

4. Methodology

This study incorporates 45 effort variables as the key independent variables. Understanding the relative contribution of each variable to students' academic performance is empirically challenging. First, the functional form of how effort affects grades is unknown. Various efforts may interact and have nonlinear effects on a student's academic performance. Assuming a simple, additive linear model using conventional OLS imposes strong parametric assumptions and might provide biased results. Multiple variables may exhibit collinearity, making isolating their marginal effects difficult. To alleviate these

concerns, I employ machine learning techniques, which offer several benefits over traditional statistical approaches.

(1) Flexibility: Machine learning algorithms can learn complex and nonlinear relationships between independent and dependent variables without imposing strict assumptions.

(2) Feature selection: Machine learning can automatically identify the most relevant variables among the 45 effort variables, providing a more concise and interpretable model than those in the literature.

(3) Model validation: Machine learning models leverage techniques such as cross-validation, which helps ensure the external validation of the findings and reduces the risk of overfitting.

(4) Robustness to multicollinearity: Machine learning methods, such as regularization techniques, can manage situations where predictor variables exhibit collinearity, mitigating the adverse effects on the model's performance.

By leveraging these advantages, machine learning techniques enable a more nuanced exploration of the relationship between various effort variables and students' academic achievements, ultimately deepening the understanding of the factors that drive educational success.

4.1 Benchmark Model: OLS

To investigate the relationship between effort factors and students' academic achievement, I first estimate the following baseline linear regression model:

$$y_i = \textbf{StudentEffort}\beta_1 + \textbf{ParentalEffort}\beta_2 + \textbf{SchoolEffort}\beta_3 + X\sigma + u_i \qquad [1]$$

Where y_i the total test scores of student i, and **StudentEffort**, **ParentalEffort**, **SchoolEffort** are vectors that include all student effort, parental effort and school effort variables, respectively. X is a control variable vector including students' demographics, parents' background characteristics, class-fixed effects and year-fixed effects. By integrating control variables in the regression, the comparison can be restricted to students with similar characteristics, which improves the precision of estimates of the effect of effort factors. u_i is the error term. The regression equation was estimated using ordinary least squares (OLS). To make the coefficients comparable, I normalize all the right-hand-side variables. This means that the coefficients of the effort variables can be interpreted as the change in academic achievements associated with a one standard deviation change in the corresponding effort variable. This normalization procedure allows us to compare the effects of different types of effort variables on academic performance in a standardized way.

4.2 Individual Variable Importance Using Machine Learning Tools

In this section, I use multiple machine learning techniques to examine the explanatory power of each effort variable. I first provide a brief introduction to the machine learning models used and then explain the analysis procedure.

Lasso. The first method used is Lasso, a widely used regularization regression technique. Lasso regression performs both feature selection and regularization to enhance the predictive accuracy and interpretability of statistical models. The objective function of Lasso is to minimize the following:

$$SSR + \lambda \sum_{j=1}^{p} |\beta_j| \qquad [2]$$

Lasso is similar to regression in that it still requires the imposition of parametric assumptions. The first term that I minimize is the sum of squared residual (SSR), equivalent to regression. However, Lasso

includes a penalty term (the second term) that ensures that it does not overfit the data and delivers good predictive performance under approximate sparsity. A key aspect of operationalizing Lasso is tuning the "complexity cost" λ, which involves selecting the appropriate value for the penalty level. The best practice is to use cross-validation to identify the optimal value for this hyperparameter.

Random Forest. The second method used is Random Forest, a tree-boosting method that achieves high prediction accuracy in many prediction tasks. Random forest is a flexible nonparametric model that can manage complex interactions among variables and is well-suited for high-dimensional data. It works by building an ensemble of decision trees on random subsets of the data and variables. This approach helps reduce overfitting and improve the accuracy and robustness of the model. The final prediction is then made by averaging the predictions of all the decision trees in the ensemble. Random Forest also provides information on variable importance, which can help identify the most important predictors of academic outcomes. To avoid overfitting, Random Forest also has hyperparameters, such as the number of trees in the ensemble, the maximum depth of the trees, and the minimum number of samples required to split a node. Cross-validation is used to select the optimal values of these hyperparameters.

AdaBoost. The third method used is another ensemble method, AdaBoost, a boosting algorithm that iteratively combines weak classifiers to create a strong classifier. AdaBoost is effective in a wide range of prediction tasks and is particularly useful for identifying important predictors. It works by assigning higher weights to observations misclassified by the current set of weak classifiers, emphasizing these observations in the next round of classification. By iteratively improving the classification accuracy of the weak classifiers, AdaBoost creates a strong classifier that accurately predicts the outcome variable. One advantage of AdaBoost is its ability to identify important predictors by assigning higher weights to more informative variables for classification. This allows a focus on the most important variables and reduces the dimensionality of the data, which can improve the accuracy and interpretability of the model.

Support Vector Regression (SVR). The last method used is SVR. SVR constructs a hyperplane in a high-dimensional space that maximally separates the data points into two classes: one for the outcome variable below a certain threshold and the other for the outcome variable above the threshold. SVR is particularly useful for identifying important variables. By selecting the most informative variables for inclusion in the kernel function, which is used to transform the input variables into a higher-dimensional space, SVR can improve the predictive accuracy of the model while reducing the dimensionality of the data. Another advantage of SVR is its ability to manage nonlinear relationships between the input and the outcome variable. SVR achieves this improvement by using a kernel function where nonlinear relationships can be more easily captured. Thus, SVR is a powerful tool for predicting continuous outcome variable and identifying the most important predictors.

Procedures for Selecting the Most Important Variables

To gain insights into the importance of individual variables, I use the following procedures:

(1) All variables were standardized before analysis to ensure comparability.

(2) The dataset was split into a training set (80%) and a test set (20%) to evaluate the performance of the models.

(3) The aforementioned four machine learning models were trained on the training set, and hyperparameters were selected using 10-fold cross-validation. In AdaBoost, decision trees were used as weak classifiers.

(4) The feature importance was sorted in descending order, and the top 20 features were selected, excluding control variables. For Lasso and SVR, the absolute value of the coefficient magnitude was used to measure variable importance. For Random Forest, the mean absolute SHAP value was used. In

AdaBoost, an importance score, calculated by summing the weights of the samples misclassified by the weak classifiers in each iteration of the boosting process, was used to measure variable importance.

(5) The test mean squared error (MSE) was computed to assess the goodness of fit of the models.

4.3 Group Variable Importance Using Machine Learning tools

Procedures for Assessing Group Variable Importance

To investigate the relative importance of each variable group (i.e., student effort, parental effort, and school effort) in predicting academic outcomes, I use the following procedures:

(1) Again, all variables were standardized, and the dataset was split into a training set (80%) and a test set (20%).

(2) Machine learning models were trained using only the variables in each of the three groups separately: student effort, parental effort, and school effort. This method allowed for a direct comparison of the relative importance of each variable group in predicting academic outcomes.

(3) The test MSE was computed for each separate model, with the variable group with a smaller test MSE indicating a higher model fit and greater importance of the variables in that group.

By comparing the test MSE across the models, I gained insights into the relative importance of each variable group in predicting academic outcomes. These results are suitable to inform educational policies and interventions aimed at improving academic performance, such as focusing on increasing parental involvement or improving teaching practices in schools.

5. Results and Discussion

5.1 Benchmark Model: OLS

Figure 2 presents the baseline OLS point estimates and 95% confidence intervals. To conserve space and avoid distraction from the focus of this analysis, I do not report the coefficients of control variables. Figure 2 suggests that several factors have a significantly positive impact on academic performance. Specifically, parents' expectations for their child's academic performance, student and parental expectations, and the presence of teachers during night study sessions have a positive and statistically significant effect on academic outcomes. Notably, parents' expectations have the strongest positive influence on educational achievement.

In contrast, certain teaching methods, such as teacher-led lectures, stratified teaching, and bilingual teaching, have a statistically significant and negative effect on academic performance. Parents' involvement in tutoring and supervision also has an adverse impact. Furthermore, the frequency of student and parent visits to museums, and parents' strictness regarding homework and exams, have negligible effects on academic achievement; their coefficients are centered around zero. Similarly, variables such as extra homework, attending extra Chinese classes or summer/winter camps, and self-perceived persistence and faith in learning, have minimal impact on academic performance; their coefficients are small.

'However, interpreting the results with caution is essential. First, including too many independent variables in an OLS model can lead to overfitting and may result in nonsignificant predictors included in the model. Second, the baseline linear model imposes strong parametric assumptions that may not hold in practice. Therefore, considering alternative methods that improve the capturing of the complexity of the data and identify the most important predictors of academic outcomes is crucial.
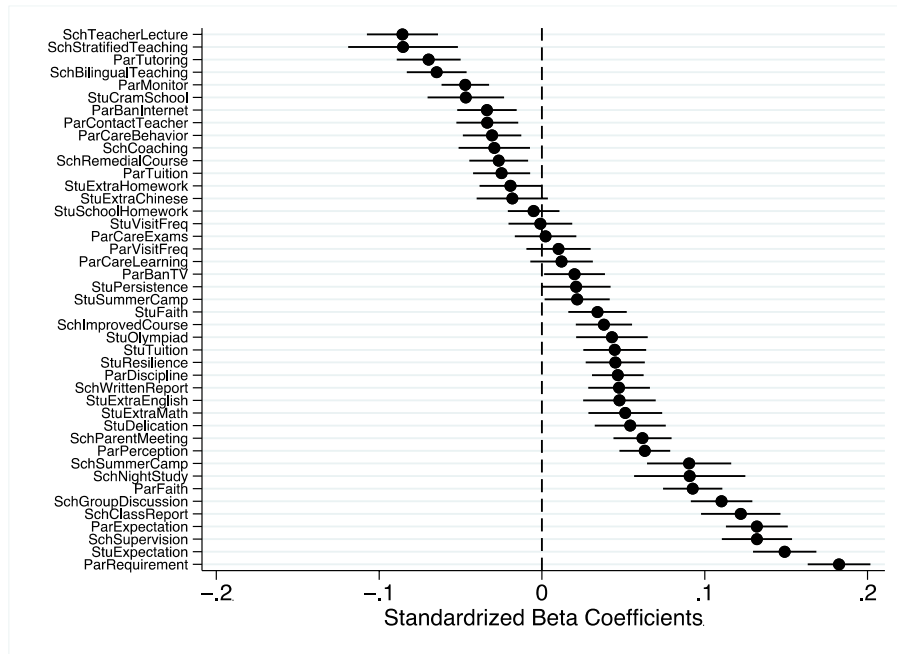
Fig. 3 Standardized Beta Coefficient Plot of OLS Estimated Effects on Academic Achievements

5.2 Individual Variable Importance

Figures 3-6 display the top 20 important predictors for academic achievement as determined by four models: Lasso, Random Forest, AdaBoost, and SVR.

Lasso, AdaBoost, and SVR produce remarkably similar results. Figures 3, 5, and 6 reveal that the most important predictor is parents' requirements for their child's academic performance (*ParRequirement*). Parents who set demanding requirements and actively engage in their child's education can provide valuable support and resources that contribute to their child's success (Boonk et al., 2018). Following *ParRequirement*, all three models predict that both students' expectations (*StuExpectation*) and parents' expectations (*ParExpectation*) are highly instrumental in forecasting academic achievement. This finding implies that students who possess higher levels of intrinsic

motivation and receive encouragement from their parents tend to perform better academically (Ryan & Deci, 2020). Furthermore, the robust predictive power of schools' practice of inviting parents to attend school events (*SchClassReport*) and having teachers supervise night study (*SchSupervision*) underscores the positive impact of a supportive school environment on students' academic success (Deming et al., 2014). Overall, these findings stress the importance of parental involvement and supportive school environments in promoting students' academic success. By prioritizing education and providing a supportive and engaging learning environment, parents and schools can help students reach their full potential (Gbollie & Keamu, 2017).

The Random Forest model produces similar predictors, although the relative rank differs slightly from that of the other three models. Figure 4 shows that student self-expectations (*StuExpectation*) rank first for feature importance, with a mean absolute SHAP value of more than 16. The school employing group discussion (*SchGroupDiscussion*) as a main teaching approach ranks second in determining students' academic performance because it can promote a collaborative learning environment that promotes critical thinking, communication, and problem-solving skills, leading to a more engaged and active learning experience (Al-Samarraie & Saeed, 2018). Parents' requirements (*ParRequirement*) and expectations (*ParExpectation*) in their child's academic records are also crucial, as shown in the previous three models.

An alternative method to interpret the results is examining the number of parental, school, and student variables ranked among the top 20 most important predictors. The machine learning models indicate that school effort is the most important factor, and student effort is the least important. For instance, in Lasso, among the top 20 predictors, 10 variables related to school effort, 7 to parental effort, and 3 to student effort. In SVR and AdaBoost, 8 variables pertained to school effort, with a higher relative rank among the top 20 predictors, and 5 variables related to student effort. Overall, school effort-related variables have greater predictive power. They are critical because they reflect the quality and

effectiveness of the educational environment. A school that provides pupils with support and resources while promoting a positive and involved learning community is more likely to improve academic achievement than a school that does not focus on these traits (Berkowitz et al., 2017).

Although the analysis examines variable importance, comparing the four models based on their in-sample and out-of-sample performance is also important. Table 2 presents the MSE values on the training and test data, with a lower MSE value indicating better performance in predicting the outcome variable. The results demonstrate that the Random Forest model outperforms the other models in test MSE, with a relatively low value of 2,318, suggesting that it fits the test data better than the other three models do. AdaBoost, another ensemble method, performs worse than Random Forest with a test MSE of 3,195, although it performs slightly better than Lasso (test MSE = 3,363) and SVR (test MSE = 3,377). Because of its flexibility and strong performance, I use the Random Forest model to assess the importance of the group variable in the next section. I use Lasso regression as a robustness check because of its interpretability.

Table 2 Comparison of Machine Learning Model Performance in Predicting Outcome Variable

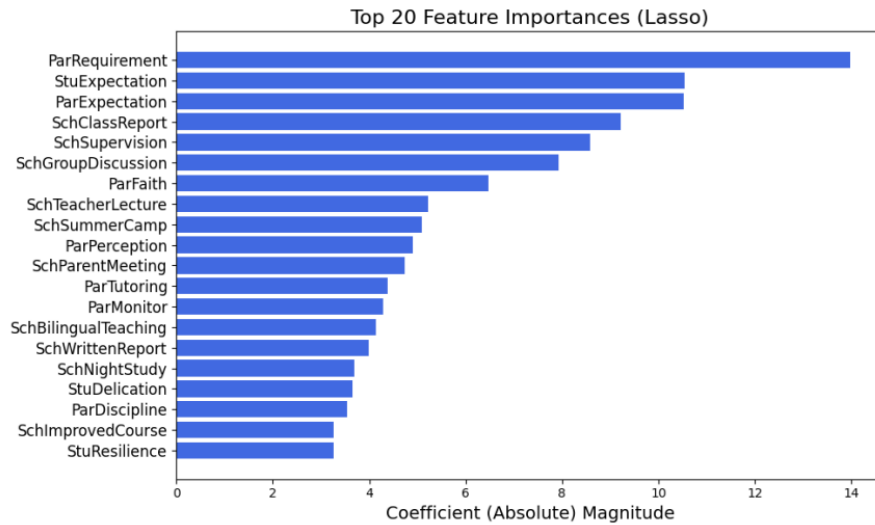|	Train MSE	Test MSE
Random Forest	317	2,318
Lasso	3,176	3,363
Support Vector Regression	3,209	3,377
AdaBoost	2,914	3,195

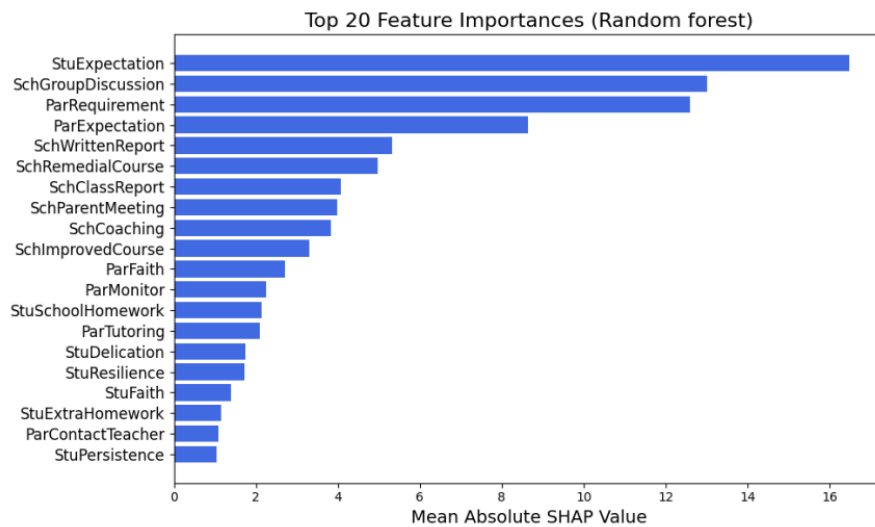**Fig. 4 Coefficient (Absolute) Magnitude of Variables Assessed by Lasso**

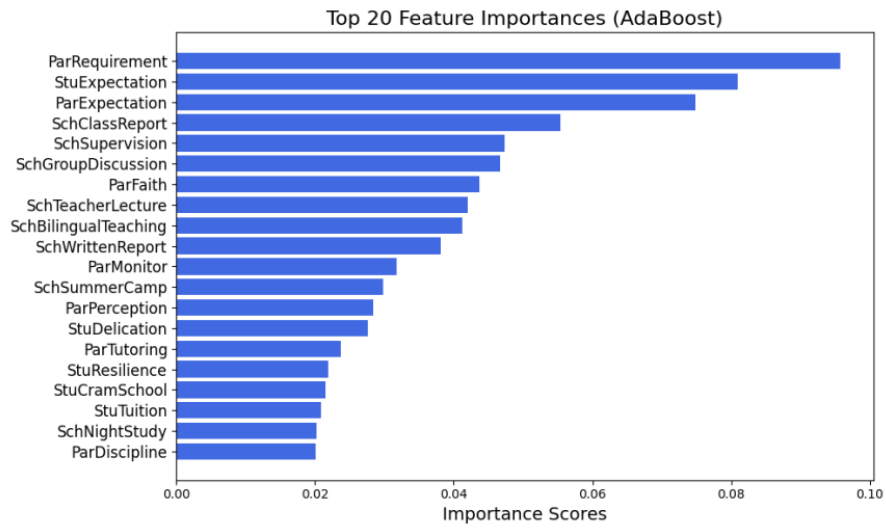**Fig. 5 Mean Absolute SHAP Value of Variables Assessed by Random Forest**

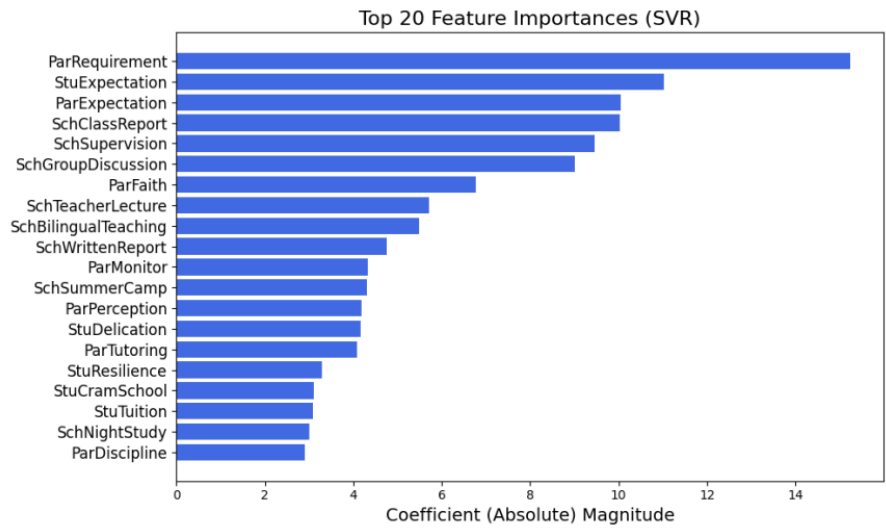**Fig. 6 Importance Scores of Variables Assessed by Ada Boost**

Fig. 7 Coefficient (Absolute) Magnitude of Variables Assessed by SVR

5.3 Group Variable Importance

Figures 7 and 8 display the results of the variable group importance analysis. The Random Forest and Lasso models predict that the "school effort" category is the strongest predictor of educational outcomes, followed by parental effort and individual effort. Using school effort variables alone yields better model prediction (lower MSE) than using parental or student effort variables.

Schools that devote considerable effort are more likely to motivate and engage students in their academic work than those that do not, leading to better academic results. One possible explanation for this phenomenon is that a supportive school environment can create a sense of belonging and motivation among students, resulting in increased engagement and effort in their academic pursuits (Won et al., 2018). When parents are involved in school events and teachers provide academic support outside regular class time, students may perceive that the school community values and supports their education (Đurišić & Bunijevac, 2017). This perception can lead to improved academic performance because students are more likely to take their studies seriously and strive for success. Additionally, the extra academic support and sense of community provided by a supportive school environment can help students overcome challenges and obstacles that may impede their academic progress (Darling-Hammond & Cook-Harvey, 2018).

Parental effort might be another critical group variable that affects students' academic achievements, responding to studies that parents' involvement and high expectations are incentives for academic improvement (Fang et al., 2018). Additionally, the demanding requirements set by parents may increase students' learning performance. This result also can be explained as follows: more effective interaction between students and parents, as a critical part of high educational investments, leads to an increase in attention and improvement in support from family (Boonk et al., 2018). In addition, when parents convey their knowledge, attitudes, and disciplines toward learning, the student's correspondingly improved

performance will evoke or "demand" additional home instruction in a virtuous cycle (Soni & Kumari, 2017).

To investigate whether there are gender differences in the impact of effort levels on academic achievement, I conduct the same analysis on samples of male students and female students. Figures 9 and 10 present the results. For girls, in academic success, school effort is more significant than parental and individual effort. For boys, parental effort is the most important factor. This gender-based difference may explain the recent trend of higher academic achievement among girls than among boys, particularly in China, where parental investments are more likely to favor boys than girls in multi-children families (Ling, 2017). Conversely, schools and teachers are more likely to provide equal incentives and resources to both genders, creating a more level playing field for girls to excel academically (Tang & Horta, 2021; Verge, 2021).

Overall, this study provides valuable insights into the factors that impact academic achievement among junior high school students in China. The findings highlight the importance of group-level factors, specifically school effort, especially academic support, in predicting academic success. A supportive school environment that engages and motivates students, and a school community that values and supports education, can have a significant impact on academic outcomes. Moreover, the study reveals gender differences in the effects of effort levels on academic achievement, with school effort being the most substantial factor for girls and parental effort being the most substantial factor for boys. Thus, policymakers aiming to improve academic performance should focus on stimulating school efforts, which is a more feasible and practical goal than attempting to change the social context of families or the resources of school hierarchies. By emphasizing the importance of school effort and parental involvement, policymakers can create a more supportive and conducive learning environment for students, improving academic outcomes and opportunities for success.
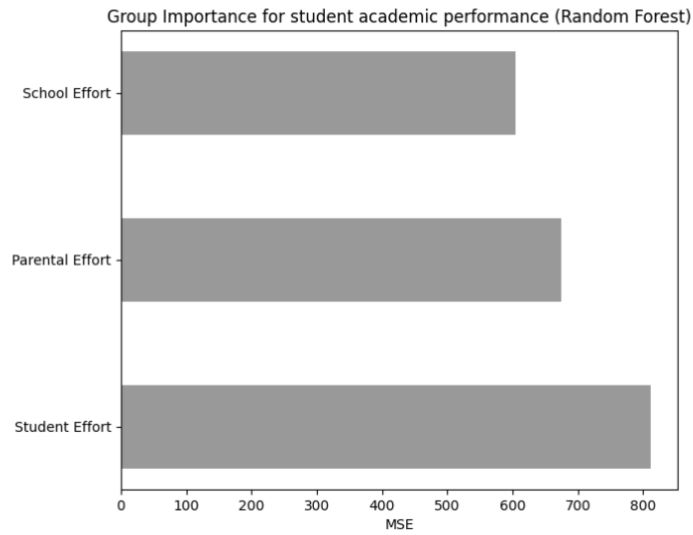
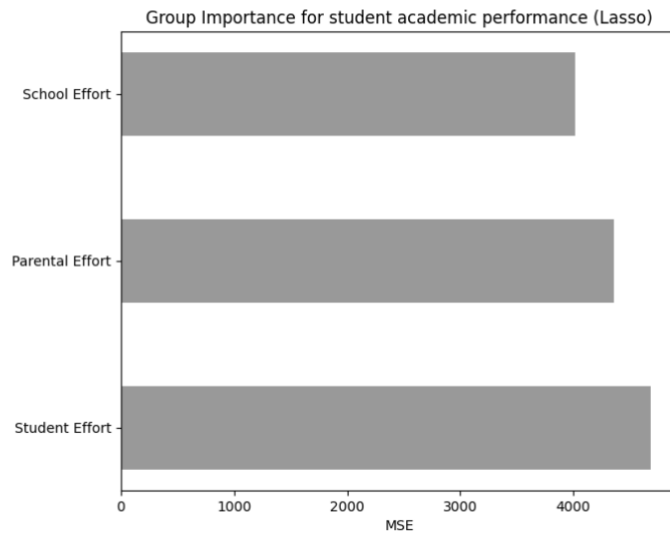**Fig. 8. Group Variable Importance Assessed by Random Forest**
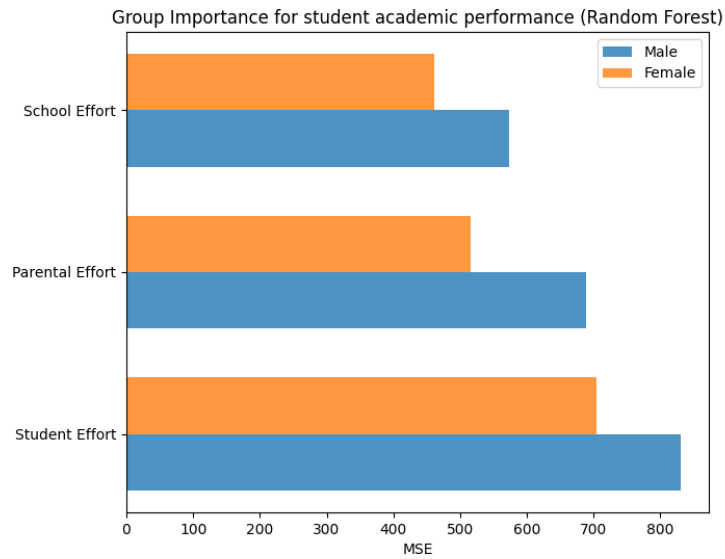

Fig. 9 Group Variable Importance Assessed by Lasso

Fig. 10 Group Variable Importance Assessed by Random Forest (by Gender)
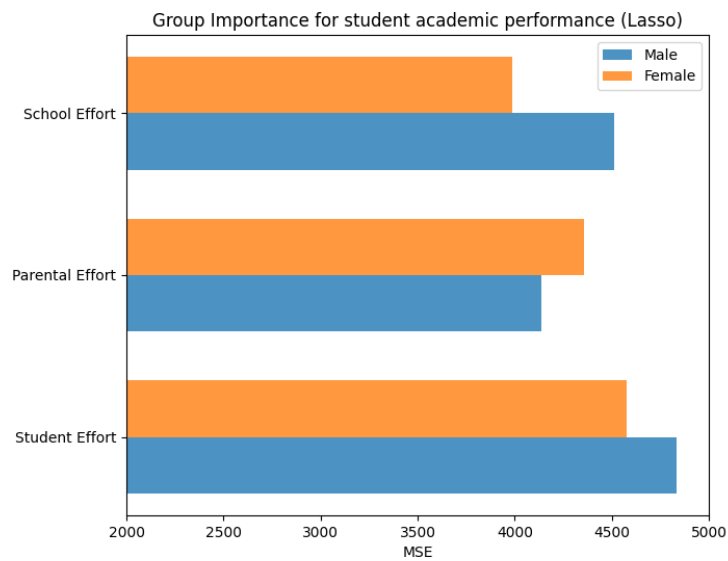

Fig. 11 Group Variable Importance Assessed by Lasso (by Gender)

6.   Conclusion and Implications

Predicting educational outcomes is crucial to policy implementation and social development. This study uses machine learning techniques to provide insights into how parental, school, and individual efforts might shape and aggravate educational inequalities. This study stresses the importance of effort as a direct predictor of student academic outcomes. It considers effort a vital driver of upward mobility in social and educational settings. If rewarding students' effortful behaviors, such as increasing their determination, perseverance, and patience regarding learning, efforts can compensate for unbalanced educational resources gained from family backgrounds to sustain or upgrade the existing academic status and future social status. The core finding of this research also indicates that efforts from both parents and schools, whether they are analyzed through their distinct variables or perceived as two group variables, are identified as decisive factors in improving educational outcomes. Therefore, future social and educational inequalities studies must consider the potential for various efforts where distinct effects exist across socioeconomically heterogeneous groups. What might be faster and more reliable than waiting for their economic circumstances to improve is to encourage effort in groups with comparatively disadvantaged social or academic status.

This study emphasizes the critical role of school efforts in improving educational outcomes. By contrast, in China, the government has primarily focused on policies aimed at strengthening school resource-based effectiveness, such as the "Quality Education" initiative that invests in teacher training and educational materials (Wang et al., 2019) and the "Double Reduction" policy that transfers academic responsibilities to families (Eryong et al., 2022). Schools should also prioritize implementing intramural motivational strategies to enhance students' self-efficacy and susceptibility to incentives (Hong et al., 2017). This approach would address outcome and effort disparities by improving the quality of in-school education across all stages of schooling. Findings in Zhu (2019) and Fu (2020) support the effectiveness

of this approach. Therefore, schools should carefully and thoughtfully design and implement motivational strategies to create a positive, supportive learning environment for their students.

On the basis of this research, I propose the following strategies to improve school efforts and students' academic performance:

(1) Increase the number of internal school programs, such as workshops, assemblies, and classroom discussions, emphasizing the link between school effort and student academic achievement.

(2) Providing personalized instruction, extracurricular events, and one-on-one support from tutors or teachers for students in need.

(3) Create a positive learning atmosphere that motivates students to participate in their studies and be responsible for their academic growth. This strategy can be accomplished by promoting an engaging and inclusive school context, providing opportunities for student leadership and collaboration, and recognizing and celebrating students' achievements.

Furthermore, recognizing the potential limitations of a prediction task is critical, for example, correlation versus causation; thus, non-causal estimates based on statistical relationships between effort-related factors and students' academic achievements may not reliably identify the variables' underlying causal impacts. As a result, the findings of this study should be interpreted with caution and supplemented with other research methods, such as randomized controlled trials, to demonstrate causal correlations. Another possible limitation is that predictive models only forecast outcomes within the range of the data used to train them, resulting in erroneous extrapolations. Thus, additional data, including that from other sources, must be collected to provide a comprehensive picture of the predicted effort variables.

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Appendices

Table 3 Operationalizations of Independent, Dependent, and Controlled Variables

Variables	Operationalizations
Academic achievement	Summed Chinese, mathematics, and English test scores
Student effort	
Time spent completing in-class homework	The total time (in hours) a student spends completing in-class homework per week.
Time spent completing ex-class homework	The total time (in hours) a student spends completing ex-class homework per week.
Time spent attending cram school	The total time (in hours) a student spends attending cram school per week.
Student self-dedication	The level of dedication a student reports for their academic work—"I would try my best to finish even the homework I dislike"—on a scale from 1 (Strongly disagree) to 4 (Strongly agree), with 1 being low persistence and 4 being high dedication.
Student self-persistence	The level of persistence a student reports for their academic work—"I would try my best to finish my homework, even if it would take me quite a long time."—on a scale from 1 (Strongly disagree) to 4 (Strongly agree), with 1 being low persistence and 4 being high persistence.
Student self-resilience	The level of resilience a student reports for their academic work—"I would try my best to go to the school even if I had any reasons to stay at home"—on a scale from 1 (Strongly disagree) to 4 (Strongly agree), with 1 being low resilience and 4 being high resilience.
Attend tuition classes (related to schoolwork) (no = 0, yes = 1)	A binary variable that measures whether students attend tuition classes outside of regular school hours to seek additional help with their schoolwork. Coded as 0 for "no" and 1 for "yes."

Participate in summer/winter camps (no = 0, yes = 1)	A binary variable that measures whether students participate in summer or winter camps related to their academic studies. Coded as 0 for "no" and 1 for "yes."
Student self-expectation	The degree of academic expectations that a student sets for themselves is measured on a scale from 1 to 10: 1 (Dropping out of school) indicates a low expectation, and 10 (Obtain a doctoral degree) indicates a high expectation.
Student self-confidence	The measure of a student's self-perceived academic confidence is rated on a 4-point scale, ranging from 1 (Not confident at all) to 4 (Very confident), with higher scores indicating greater confidence and lower scores indicating lower confidence.
Attend International Mathematical Olympiad (IMO) class	A binary variable that measures whether the student attends IMO class: 1 indicates attendance, and 0 indicates nonattendance.
Attend extra Mathematics (exclude IMO) class	A binary variable that measures whether the student attends extra Mathematics (exclude IMO) class, with a value of 1 indicating attendance and 0 indicating nonattendance.
Attend extra Chinese class	A binary variable that measures whether the student attends extra Chinese class: 1 indicates attendance, and 0 indicates nonattendance.
Attend extra English class	A binary variable that measures whether the student attends extra English class: 1 indicates attendance, and 0 indicates nonattendance.
Frequency of visits to museums	How frequently the student visits museums, ranging from 1, the least frequent, to 6, the most frequent.

Parental effort

Help with their child's homework	The amount of help parents provide to their child with their homework on a scale from 1 (There is no need to help) to 5 (Yes, help is provided almost every day).
Supervise their child's homework	The level of supervision parents provide to their child while they complete their homework on a scale of 0 (Not at all) to 4 (Completely).

Frequency of parental visits to museums with their Child's	The number of visits to museums by parents with their child on a scale from 1 (Never) to 6 (More Than Once a Week).
Parents talk to teachers about their child's learning	A binary variable that measures whether parents communicate with their child's teachers about their learning: 0 (No) to 1 (Yes).
Whether parents proactively contact teachers	The level of proactivity demonstrated by parents in contacting their child's teachers on a scale from 1 (Never) to 4 (five times or more).
Parental discipline for their child	A binary variable that measures the level of discipline imposed by parents on their child on a scale of 0 (no discipline) to 1 (high discipline).
Parents enrolling their Childs in tuition	A binary variable that measures on a scale from 0 (no enrollment) to 1 (enrollment) whether parents enroll their child in tuition classes.
Parents' concern for their child's effort level	A binary variable that measures on a scale from 0 (low concern) to 1 (high concern) the level of concern parents have for their child's effort in their academic work.
Parents' requirements for their child's performance	The level, on a scale from 1 (No special requirement) to 4 (Being one of the top five of his/her class), of the academic record parents require from their child.
Parent's educational expectations for their child	The level, on a scale from 1 (Drop out now) to 9 (Obtain a doctoral degree), of educational expectations parents have for their child.
Parent's faith in their child	The level, on a scale from 1 (Not confident at all) to 4 (Very confident).
Parents being strict about their child's homework and exams	The level, on a scale from 1 (I don't care) to 3 (I'm very strict about it), of strictness parents impose on their child's homework and exam performance.
Parents being strict about their child's school behaviors	The level, on a scale from 1 (I don't care) to 3 (I'm very strict about it), of strictness parents impose on their child's behavior in school.

Parents being strict about their child's time spent on the internet	The level, on a scale from 1 (I don't care) to 3 (I'm very strict about it), of strictness parents impose on their child's time spent on the internet.
Parents being strict about their child's time spent on TV	The level, on a scale from 1 (I don't care) to 3 (I'm very strict about it), of strictness parents impose on their child's time spent watching TV.

School effort

School requires students to attend night study	A binary variable that measures whether the school requires students to attend night study or not; the scale is 1 (No), 2 (Yes, Grade nine only), and 3 (Yes, Grade seven and Grade nine).
Teachers on duty for night study	A binary variable that measures the teachers' involvement in night study: 0 (No) and 1 (Yes).
School organizes summer/winter camps for students	A binary variable that measures whether the school organizes summer/winter camps for students: 0 (No) and 1 (Yes).
Frequency of school sessions on academic/life coaching	The frequency of school sessions on academic/life coaching, with 1 (Never) indicating low frequency and 4 (Over five times) indicating high frequency.
Availability of teacher training	A binary variable that measures whether the school provides training programs for teachers: 0 (No) and 1 (Yes).
Partnerships with local businesses for additional resources	A binary variable that measures whether a school has partnerships with local businesses and organizations for additional resources for students: 0 (No) and 1 (Yes).
Frequency of parent-teacher meetings	The frequency of parent-teacher meetings, with 1 (Never) indicating low frequency and 4 (Over five times) indicating high frequency.
Frequency of written reports from the school to parents	The frequency of written reports from the school to parents, with 1 (Never) indicating low frequency and 4 (Over five times) indicating high frequency.

Frequency of schools inviting parents to observe	The frequency of schools inviting parents to observe, with 1 (Never) indicating low frequency and 4 (Over five times) indicating high frequency.
Main teaching methods: teacher-led lectures	A binary variable that measures whether the school's main teaching method is teacher-led lectures: 0 (No) and 1 (Yes).
Main teaching methods: group discussions	A binary variable that measures whether the school's main teaching method is group discussions: 0 (No) and 1 (Yes).
Main teaching methods: bilingual teaching	A binary variable that measures whether the school's main teaching method is bilingual teaching: 0 (No) and 1 (Yes).
Main teaching methods: stratified teaching	A binary variable that measures whether the school's main teaching method is stratified teaching: 0 (No) and 1 (Yes).
School takes remedial classes for students with failing grades	The level of remedial classes offered to students with failing grades, with 0 indicating that no remedial classes are offered and 4 indicating a high level of remedial classes.
School offers advanced study for students good at a single subject	A binary variable that measures whether the school offers further enhanced opportunities to outstanding students: 0 (No) and 1 (Yes).

Controls

Gender (male = 0, female = 1)	A binary variable that indicates students' gender, coded as 0 for male and 1 for female.
House registration type (rural = 0, urban = 1)	A binary variable that indicates students' house registration type, coded as 0 for rural and 1 for urban.
Cognitive ability	An ordinal variable that indicates students' cognitive ability, ranging from 0 to 35.
Family structure (only-child = 0, non-only child = 1)	A binary variable that indicates students' family structure, coded as 0 for only-child and 1 for non-only child.

Health condition	An ordinal variable that indicates students' health condition, using a rating scale of 1 to 5, with 1 being very poor health and 5 being very good health.
Parent's educational level	This variable is measured by asking the parents about their educational qualifications and coding them as follows: 1 for None, 2 for Finished elementary school, 3 for Junior high school degree, 4 for Technical secondary school or technical school, 5 for Vocational high school degree, 6 for Senior high school degree, 7 for Junior college degree, 8 for Bachelor degree, and 9 for Master degree or higher.
Parent's occupation	This variable is measured by asking the parents about their occupation and coding them as follows: 1 for unskilled worker, 2 for skilled worker, 3 for clerical or sales, 4 for service worker, 5 for small business owner, 6 for professional, 7 for executive or managerial, 8 for retired, 9 for unemployed, 10 for student, 11 for homemaker, 12 for farmer, 13 for other.
Parent's income	This variable is measured by asking the parents about their income level and coding it on a scale from 1 (Very poor) to 5(Very rich).
Separate studying desk available (no = 0, yes = 1)	A binary variable that measures whether a family has a separate studying desk for the child: 0 (No) and 1 (Yes).
Computer and internet available (no = 0, yes = 1)	A binary variable that measures whether a family has computer and internet access: 0 (No) and 1 (Yes).
School ranking	This variable is measured using a scale from 1 to 5, with 1(Near the bottom) being the lowest-ranked school and 5 (Among the best) being the highest-ranked school.
School category (private = 0, public = 1)	A binary variable that measures whether the school is 0 (private-funded) or 1 (public-funded).
School size	This variable is measured by the number of classrooms owned in the school, ranging from 5 to 400.
Student-teacher ratio (teacher = 1)	This variable is measured by the number of students per teacher (teacher = 1), ranging from 3 to 30.80.
School fiscal per year	This variable is measured by the amount of money allocated for the school's operation per year, ranging from 0 to 100.

Table 4 Descriptive Statistics for Controlled Variables

Controls

Individual demographic characteristics

Gender (male = 0, female = 1)	StuGender	0.486	0.500	0	1
House registration type (rural = 0, urban = 1)	StuHukou	0.458	0.498	0	1
Cognitive ability	StuCognition	13.90	8.134	0	35
Family structure (only-child = 0, non-only child = 1)	StuOnlyChild	0.563	0.496	0	1
Health condition	StuHealth	4.144	0.866	1	5

Family background characteristics

Parent's educational level	ParEducation	4.075	1.995	1	9
Parent's occupation	ParOccupation	6.543	2.614	1	14
Parent's income	ParIncome	2.809	0.601	1	5
Separate studying desk available (no = 0, yes = 1)	StuOwnDesk	0.789	0.408	0	1
Computer and internet available (no = 0, yes = 1)	StuOwnInternet	0.620	0.485	0	1

School resource characteristics

School ranking	SchRanking	3.948	0.845	1	5
School category (private = 0, public = 1)	SchCategory	0.923	0.266	0	1
School size	SchSize	40.62	40.55	5	400
Student-teacher ratio (teacher = 1)	SchTeacherRatio	13.33	4.537	3	30.8

School fiscal per year	SchFiscalYear	33.17	42.63	0	100
N	24,974				

Control variables

Student demographic characteristics. To control for the potential influence of student demographic characteristics, I include 5 student demographic variables as control variables: gender (male = 0, female = 1), family structure (only child = 0, non-only child = 1), health condition (rated on a scale from 1 = very poor to 5 = very good), and house registration type (rural = 0, urban = 1). Table 4 displays the distribution of these variables in the sample, with male students comprising 52% of the sample and female students comprising 48%. Of the students, 56% reported having siblings, and 41% reported being healthy. In addition to demographic variables, cognitive ability is an important factor in academic success. The CEPS used a 35-question cognitive ability test administered to junior high school students to measure cognitive ability. On average, the students correctly answered 14 of the 35 questions. Higher scores on the test indicate higher cognitive ability levels.

Family background characteristics. Family background, often reflected in parents' income, professions, and educational levels, is a crucial predictor of academic achievement and potentially affects students' and parental efforts. To control for these factors, I collect data from 5 answers from parents' questionnaires. As shown in Table 4, 72% of moderately affluent families, 40% of parents have completed at least a junior high school degree, and 53% of parents have obtained higher-level occupations such as technical worker, teacher, engineer, doctor, lawyer, and government official. In addition, I also consider the availability of a separate studying desk, computer, and internet at home because limited access to these resources can create inequities in academic opportunities and outcomes.

Descriptive statistics indicate that approximately 79% of students have a separate studying desk, and 62% are equipped with a computer and internet at home, potentially facilitating their learning process.

School resource characteristics. To account for the influence of school characteristics on academic achievement and effort levels, I include 5 variables related to the school's resources. One such variable is school ranking, which is determined based on academic performance and is represented by higher values indicating better performance. Of the total sample, approximately 79% of schools have above-average rankings and are considered among the best. Regarding school categories, 92% of schools are public-funded, and the remaining 7.47% are private schools. Additionally, the size of schools is considered, with approximately 80% having a below-middle size that accommodates 50 or fewer classrooms. The teacher-to-students ratio is also a factor; 26% of schools have adequate teachers, with a teacher-to-students ratio of less than one: ten (one teacher for ten students). Last, I include fiscal resources available to schools per year, with 55% of schools eligible to receive provincial-level funding annually.

Acknowledgements

This dissertation would not have been possible without the assistance of some very people. I sincerely appreciate everyone who contributed to this research work in any way, direct or indirect. Hence, I am glad to express my heartfelt gratitude:

To Prof. Dr. Eva Jablonka, for throwing her faith and confidence in me for this complicated, cross-disciplinary, and challenging task, and for providing valuable instruction, feedback, and advice, as well as inspiring encouragement at every step of the way. Without her expertise, continuous support, and timely guidance, my efforts would not gain any reward.

To Prof. Dr. Uwe Gellert, for actively supporting my participation in this doctoral program from the start and assisting me in organizing my thoughts in order to develop a research plan. His kindness, generosity, and unconventional outlook have provided me with endless inspiration.

To my closest LEADing friends throughout this adventure, Zun HUANG, Di CAI, Kang DONG, for always being reliable, loving, supporting, and understanding with me.

To Siying XIE and Dan LI, thank you for inspiring me day after day with your kindness, cheerfulness, and efforts to ensure my well-being. I am so lucky to have met you in Berlin.

To my family, for always being optimistic about my endeavors and empowering me with their courage, perseverance, and endless love. I could only make it so far because they grant me such grit bred-in-the-bone.

Finally, to Chaolu WANG, for always having faith in me, reassuring me of my positives and aspirations when I questioned myself, and being patient, appreciative, and forbearing all the time. I am so glad we leaped over it together.